PHYSIOLOGY
AND ANIMAL MECHANISM.

FIRST-BOOK
OF
NATURAL HISTORY,

PREPARED FOR THE USE OF

SCHOOLS AND COLLEGES.

BY

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FROM THE TEXT OF

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PREFACE.

The original text of this volume forms the first of a series of First Books on Natural History which were arranged and published by men distinguished in science, under the direction of the "ROYAL COUNCIL OF PUBLIC INSTRUCTION OF FRANCE," for the Use of Schools and Colleges of that country. These First Books or Primers are seven in number, and embrace the following subjects, each complete in itself.

No. 1. General Notions on Physiology, and Animal Mechanism.

No. 2. Zoology, or the Natural History of Mammiferous Animals.

No. 3. Ornithology, or the Natural History of Birds.

No. 4. The Natural History of Reptiles, Fish, and Molusca.

No. 5. The History of Insects, of the Crustacea, Arachnides, Annelides, and Zoophytes.

No. 6. Botany; and

No. 7. Geology.

The great care which has been bestowed in the preparation of these Primers, and their almost unparalleled popularity in France, hundreds of thousands having been sold in the course of a short time, has led me to offer to the public, the first of the series: Should this little work be favourably received, the other primers will be prepared in a similar style and offered to the American public.

The work does not pretend to be more than a mere outline, and is chiefly designed as an introduction to the study of natural history; but it treats sufficiently of Physiology and animal mechanism, to be well adapted to the use of schools, as well as for young persons, and even others who have not the opportunity or inclination to study the subject in professional treatises. Each branch of the subject is treated of in as few words as perspicuity will

permit. The reader is led on from point to point, and is informed in the progress of the work of all that is requisite to enable him to understand generally, the phenomena of the circulation of the blood, respiration, digestion; and the structure, and mode of operation of the several senses are clearly set forth.

One considerable objection to the several highly meritorious works which have been, within a short period, presented to the public on popular physiology, namely the price, being too expensive for general use in common schools, has been obviated in this.

In order to render this little book more complete for the use of schools, I have added, at the foot of each page, questions upon the text, which in many instances serve to illustrate it, and also a short glossary of such words as are used in a technical sense. When the character of the plates, and the matter of the work, are taken into consideration with the very small sum for which it is afforded, it is hoped, it will meet with a proper reception.

Philadelphia, June 1. 1841.

INTRODUCTION.*

Natural History, which may be defined the intelligent contemplation of the works of God, is in a manner the most certain and the most noble subject, that can occupy the mind of man. In it alone, human genius is in full possession of certainty. Philosophy, politics, history, and morality itself, are subject to the intellectual revolutions of wavering humanity; but the facts of the Creation are as invariable as God, and the analysis obtained from a plant or an insect, marks its demonstration with the seal of eternal truth.

The double effect of the study of Natural History is to impart certainty to the mind, and religion to the heart. The creation is as a visible ladder by which man ascends towards the invisible Creator.

Natural History, the science which is the mother of all sciences, embraces the whole world; physical knowledge, mathematical knowledge, are all comprehended in its domain; and, as we have just said, the teachings of morality, here mingle of themselves, without any effort, with thoughts of religion.

It has been said that Natural History should be the only reading-book of the people; I would add, it should be the first book of childhood. Of all the means which we may successfully employ for awakening the intellect of young people, there is none, the results of which are more certain or more durable than curiosity; the desire to know is as natural as reason; it is vivid, and active at every period of life, but it is never more so than in youth, when the mind, destitute of knowledge, seizes upon all that presents itself with avidity, and willingly gives the attention and study necessary to know, and very naturally contracts the habit of reflection and of being occupied.

It is not the labours of the learned that are to be brought to the attention of infancy, but a study of nature, to comprehend which requires scarcely anything but eyes and which consists in examining carefully the objects of nature, in order to admire their beauties, without diving into their hidden causes. Children are capable of this study, for they have eyes, and they have curiosity; they desire to know, and they are inquiring. A garden, a field, a palace, all is an open book for them; and they should be taught to read in it. "It is inconceivable," says Rollin, "how much children might learn if we could profit by the opportunities which they themselves afford us." To seize upon these opportunities should be a desideratum with instructors and parents.

*Extracted from the "Atlas Methodique," of Natural History.

Frivolous pretexts have for a long time been urged against the teaching of Natural History, and even when the description of a few plants, and insects was permitted, the book was hastily closed before the reader arrived at the study of man, without dreaming that this study which Galen pronounced, a *hymn to divinity*, takes its place amongst those branches of knowledge most honorable to his genius.

By examining the material springs of his being, man accustoms himself to raise his thoughts to their author and preserver; the more he considers their wonderful organization, the more he feels the necessity of seeking beyond himself for the Supreme Cause; it is at this moment, he feels the insufficiency of his own limited explanations to deceive the human mind into a gross materialism, and that he feels assured that this machine, which goes of itself, is regulated by a superior wisdom to his own. Constrained then to seek a motive beyond the circle of physical causes, his enlightened reason reveals to him the immaterial agent who binds all things and directs them by rules, and to the end, which he judges to be proper.

These ideas, however reasonable they may appear, were in nowise admissible only a few years ago; the fear of weakening religious sentiment gave rise to that banishment to which Natural History was condemned; and nothing less than the imposing authority of the great naturalist, whose grievous loss the Sciences will for a long time deplore, nothing less than the constancy of his efforts and the powerful influence of the example afforded in himself, were sufficient to win over to his opinion, those great men to whom is confided the direction of public instruction.*

M. Cuvier was happy in making them feel the necessity of uniting to the study of antiquity, the greatest, the most sublime, and most durable spectacle of all nature and the laws which preserve it in harmony, and, that Natural History, which, only in our day, has grown to be of importance, is an indispensable element in a good education.

The habit which one necessarily learns of classifying a great number of ideas in his mind, and the art of methodizing, said he, when once properly acquired, apply with infinite advantage to studies the most foreign to that of Natural History. Every discussion which supposes a classification of facts, every research requiring a distribution of materials, must be conducted on the same laws, and the youth who in the beginning, thought to pursue this science only as an amusement, is surprised at the facility with which it enables him to disentangle and arrange affairs of all kinds.

By proper management and precaution with children, it is easy to avoid all, that, by opening to it routes deceptive to their early thoughts, might cause the imagination to err. Natural History is a science of facts;

* In France.

and one may, therefore, confine himself to the description of observable facts, and he will find nothing in them, the knowledge of which can be, in the slightest degree, at variance with morality or religion. These elementary notions, early imparted to children, will contribute to the progress of their minds and reason, render the other studies to which they may dedicate themselves, more easy and more brilliant, and will serve as a basis to the more profound knowledge they may acquire in riper years.

The spectacle of Nature is the striking assemblage of all that is most wise, most beautiful, most simple, and most wonderful; all this, however, would be ephemeral, if God had not the secret of uniting together all these productions, of perpetuating them in an immutable order, and of placing man in the midst of this ever moving scene, that he might be as the mirror wherein are reflected the various images of the universe.

Man was a necessity to the creation; and it is with him alone that the intelligence of created things began.

Bacon has given an admirable definition of science: "Science," says he, "is man added to nature." In vain would the earth open its bosom to show in broad day the combinations of its metals, the agglutination of its stones or the chrystallization of its salts; in vain would the emerald or topaz exist in transparent columns, and the waters gush through the rent rocks in limpid and living streams; all these sublime phenomena would be without value, without object; in a word, Nature would not be understood, if man had not been created to know and describe her.

Indeed, if we carry our thoughts back to the primitive ages of the world, to those epochs that preceded the appearance of man upon the earth, we discover that all the imagination finds to dwell upon is gigantic, without form and monstrous; the mind passes in fear from the account of a revolution to the history of the deluge, where there is nought but destruction and submersion, painful labor and abortion. Pyrites enkindle the volcanoes; burning sulphur perpetuates these vast conflagrations; boiling waters are decomposed in their fires; from these craters rush forth flames and burning lava; their accumulations are projected into the midst of rivers, and turn them violently from their course; electric detonations shake the earth far and wide, and open it in frightful rents; the ocean beholds its bed torn up by volcanic eruptions; new isles raise their smoking heads above the waves; and, too ponderous for the pedicles that support them, like some magic promontories, they soon disappear, and the heaps of their ruins form the base of steep rocks which may at some future time become vast continents.

In these incoherent preludes we perceive chaos; and it is only at remote periods we are permitted to detect some unfinished phenomena of an uncertain and incomplete life, a life which struggles against nihility, and overcomes it only with difficulty, a life that would take possession of the globe, and which contends against the laws of inert matter, the dominion of which is universal.

In this, then, behold what nature was without man. . . . But if man appear, if, to recur to the brilliant thought of Bacon, "*man is added to nature*," then Creation has a voice, a value, a sense. Of the innumerable crowds of animals, and of plants that share between them the domain of the earth, and of the marvellous events that renew the face of things, man has become the master and the historian; all have an equal right to his admiration, all are equally subjects of his study. From the almost imperceptible mould to the colossal productions of the vegetable kingdom, from the microscopic animalcule to the elephant and the whale, from the atom of sand to the summit of Atlas, he interrogates, he comprehends, he explains them all. Imagination is no longer at the expense of inventing brilliant pictures; truth alone strikes his mind and elevates his soul, and, in place of the confused reveries inspired by chacs, appears a science of wisdom, of reason, and of order, which, in a word, is NATURAL HISTORY.

The individual who enters a field, or strolls upon the bank of a stream, or roams through the forest, if he comprehend the elements of Natural History, may read a pleasant story and acquire information, at every step, from the great book of nature, which every where lies open wide before him; but if ignorant of Natural History, this magnificent and varied work is to him no more than is a printed volume to one who never learned a letter. Natural History not only affords us the means of endless amusement, but teaches us to discover the riches of the earth, and to gather from them the means of ameliorating and improving the condition of man.

CONTENTS.

GENERAL NOTIONS

ON

NATURAL HISTORY.

LESSON I.

The Natural Sciences and their Divisions—Definition of Zoology—General knowledge necessary to its successful study—The structure of animals, and enumeration of their principal organs—Classification of the functions of animals.

1. The Natural Sciences have for their object, the study of those beings, the assemblage of which compose the universe.

This study is divided into many distinct branches; but these branches are all so linked, one to the other, as to afford a mutual support.

2. The different branches of the Natural Sciences are: Physics, Chemistry, Astronomy, Meteorology, and Natural History.

3. The name *physics* is given to that science which embraces the consideration of the general properties of matter; which studies the motions of bodies, as well as Heat, Light, Electricity, Attraction, and which applies the knowledge thus acquired to the explanation of the great phenomena of nature.

4. *Chemistry* has for its object, the knowledge of the intimate composition of bodies, and the various combinations which may be made from them. It teaches us what are the forming elements of different bodies, and how these elements, by combining in various ways, may give rise to other bodies, and enables us to understand the properties of all these substances.

5. *Natural History*, taken in its most general acceptation, should include the study of the form, of the structure, and of the mode of existence of all the bodies of nature, individually considered; but, by common consent, the domain of this science is

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1. What is the object of the natural sciences?
2. What are the different branches of the natural sciences?
3. What does the science of physics embrace the study of?
4. What has chemistry for its object? what does it teach?
5. In the most general acceptation of the term, what is included under the name of natural history?

more limited, and all that has not a direct relation to the physical history of our globe and the beings spread over its surface, is excluded. Consequently, it does not embrace the study of the stars, nor of meteors, nor even of the air which surrounds our globe; or, in other words, it comprises neither astronomy nor meteorology.

6. *Astronomy*, if we may so express ourselves, is the natural history of the celestial bodies; by the assistance of observation and calculation, it applies the general laws of physics to the study of the phenomena which the celestial bodies present, and thus determines their form, their volume, the distance which they are separated from our globe as well as from each other, and the movements which they perform in space.

7. *Meteorology* is in some measure the natural history of the atmosphere; it inquires the origin of thunder, of rain, of hail, of the dew, of falling or meteoric stones, (aërolites), and of the various meteors which appear in the heavens.

8. Natural History properly so called, we repeat, extends its domain over the structure of our globe, and over all the beings found upon its surface.

9. These beings are separated into three groups or kingdoms; the mineral kingdom; the vegetable kingdom and the animal kingdom; in this way Natural History is divided into three branches:—

10. *The natural history of Minerals, and that of the terrestrial globe, which is formed of them, bear the names of* MINERALOGY, *and* GEOLOGY.

11. *The natural history of Plants is called* BOTANY.

12. *The natural history of Animals is termed* ZOOLOGY.

It is the last of these which is to occupy our attention at present.

13. The study of animals, as well as the study of plants, is subdivided into three principal branches, according as they are considered in respect to:

1st, The characters which distinguish them one from the other, the climate they dwell in, their habits, &c.;

2nd, The internal structure of their bodies;

3rd, The play of their organs and the manner in which they respectively produce the various phenomena of life.

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6. What is Astronomy?
7. What is Meteorology?
8. What is Natural History properly so called?
9. Into how many kingdoms is Natural History divided? What are they?
10. What is Mineralogy? Geology?
11. What is Botany?
12. What is Zoology?
13. How is the study of Animals and Plants divided?

These three branches of the natural history of animals and of plants, eonstitute three sciences which are known under names of *Zoology*, (*or, when plants are referred to, descriptive Botany*,) *Anatomy*, and *Physiology*.

14. ANATOMY *treats of the internal conformation of living beings;* it studies them by the aid of disseetion, and acquaints us with the position, the form, and the structure of their organs. In as much as it has for object the eonsideration of either animals or plants, it constitutes two distinct seienees: *Zoological Anatomy, and Vegetable Anatomy*.

15. PHYSIOLOGY *is the Science of Life;* it teaches the use of different organs, and the manner in which these aet, to produce the different phenomena, (that is, visible qualities), proper to living beings. Like Anatomy, it may have for its domain either the animal or vegetable kingdom, and it is consequently divided into *Animal Physiology*, and *Vegetable Physiology*.

16. It is easy to understand that, without the aid of Anatomy and Physiology, the profound study of natural history would be impossible. When we wish to obtain an exact idea of a watch, we do not limit ourselves to observing its exterior form, and to notieing the manner in which the hands turn; we open it, we examine every wheel, every chain, every spring:—we would separate them one by one, and study the relations which they have to eaeh other, and we would seek to understand their use; afterwards, we should again put together all these pieees, and by re-establishing their mutual relations, restore what we had taken from them; that is, their movements and their play.

Now, what the watchmaker does to obtain exact knowledge of a wateh, the naturalist does, as far as he is capable, to study an animal or a plant; by disseetion he examines the interior of its body, separates the different organs, determines their relations, and studies their form and nature; then he observes their play during life, and, by making experiments, beeomes aequainted with their uses. Unfortunately the naturalist eannot do all that the watehmaker does; he ean destroy, but he cannot re-eonstruet what he has deranged, and restore movement to organs whieh he has separated to study their structure—nevertheless, by anatomieal investigation, by observation of the vital phenomena and by physiologieal experiments, he aseertains the mechanism of these

14. What is anatomy? what does it teach?

15 What is physiology? what does it teach? what is animal physiology? what is vegetable physiology?

16. Why is a knowledge of anatomy and physiology necessary to understand natural history?

complicated machines, and succeeds in satisfying ardent curiosity, which is one of the characteristic traits of superior intelligence.

No study can be more grand, or more interesting; in revealing what is extraordinary in animal organization, it leaves us filled with admiration at the sight of this infinite, this most astonishing work of the Creator.

Considered in their mechanical relations alone, the bodies of animals present us examples of complication and perfection, to which our best constructed and most perfect machines do not approach: here we find without number, models of ingenious contrivances, of which, the most successful labors of the architect or optician have produced but imperfect copies.

But these are the least of the wonders which the animal economy offers us. The forces, which put into action all the material springs of our body, are regulated and combined with a wisdom which is far beyond human science; and the more we contemplate the play of our organs, and the faculties with which they are endowed, the more we feel the necessity of recurring to the Superior Intelligence who has created this admirable production, and who has placed in it, a principle of existence and of movement.

To study with profit the particular history of different animals, it is necessary, as we see, to possesss some general notions of their anatomy and physiology; and it is this preliminary knowledge which is to engage our attention in the first of our course.

Of the general composition of Animal Bodies, and the functions performed by their different organs.

17 All living beings are formed of a union of solid and of liquid parts.

18. The solid parts are composed of small fibres and little plates, so arranged as to contain the liquid parts, in spaces left between them; they thus form textures or tissues of various kinds, and we give the name of *organization* to the disposition which the tissues assume.

19. Organized bodies, that is, bodies having an organization or mode of structure which we have just indicated, are the only living beings; because this internal conformation is necessary to the maintenance of life: therefore, non-organized or inorganic bodies, as stones, and metals are incapable of living.

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17. Of what are living beings formed?

18. Of what are the solid parts composed? what is meant by organization?

19. What are organized bodies? Why are stones and metals incapable of living?

20. The different phenomena by which life manifests itself, are always the result of the action of some part of the living body; and these parts, which may be regarded as so many instruments, are called ORGANS.

21. Thus, an animal cannot move without the action of certain *organs* called muscles, or attain a knowledge of that which surrounds him except by the intervention of the *organs* of sense.

22. When several organs concur to produce the same phenomenon, the assemblage of instruments is termed an APPARATUS.

23. We say, for example, *the apparatus of locomotion* to designate the assemblage of organs which serve to transfer an animal from one place to another; and, *apparatus of digestion* to designate the assemblage of organs, by the assistance of which the animal digests its food.

24. The action of one of these *organs*, or of one of these *apparatus*, or the use for which they are designed, is called a *function.*

25. We say, therefore, *function of locomotion*, to designate *the action* of all the parts of the apparatus of locomotion; *the function of digestion*, to designate the *action* of the different parts which constitute the digestive apparatus; and *functions of the stomach, functions of the intestines, functions of the teeth, &c.*, to designate the *uses* of these different organs. With man, as well as with all quadrupeds, birds and a majority of other animals, the organs, and the functions which the latter exercise, are very various.

26. Considered individually, the body of the majority of animals is divided into three principal portions; the *head*, the *trunk*, and the *members*, or extremities.

27. The *head*, which is not found with all animals, oysters for instance, is subdivided into two parts; the *cranium* or skull, and the *face*.

28. The *trunk* is composed also of two parts; the *chest* or *thorax*, and the belly or *abdomen.*

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20. What is meant by an organ?

21. Give an example of an organ?

22. What is an apparatus?

23. What are the examples of an apparatus?

24. What is a function?

25. Give examples of what is meant by the term function.

26. How are the bodies of animals divided?

27. Does every animal possess a head? What are the divisions of the head?

28. Of how many parts is the trunk composed? What are they?

29. In most of the animals at present referred to, the *members* exist in double pairs, and are distinguished as *superior*, or *thoracic*, and *posterior* or *abdominal*, or *inferior* members, or extremities. Certain animals, such as the whale, have only a single pair; others, such as serpents, have none at all, and others again have a considerable number; insects have three pairs of feet, spiders four pairs, crabs and lobsters five pairs, the wood-louse, or palmer, seven pairs, and certain worms have as many even as five hundred pairs.

30. In all these animals, the body is enveloped on all sides in a resisting membrane, endowed with sensibility, which is termed the *skin;* it is secured from the inside, and its general form is determined by a solid frame, composed of a number of bones, called a *skeleton*, (*plate* 6, *fig.* 1.) Farther on we shall enumerate these bones, speak of their names and various forms.

31. The skeleton does not exist with all animals; oysters and snails for example are without it; and with others again, such as lobsters, the skin acquires an extreme hardness, and answers in place of this bony frame; but with all mammiferous animals, birds, reptiles and fish, there exists a skeleton, arranged in a manner analogous to that of man.

32. Between this internal frame and the skin or external envelope, are found the muscles, which constitute what is commonly called *flesh*, whose function is to produce, by their contractions, all the motions which the animal performs; between these muscles are placed the vessels which carry the blood to different points of the body, the nerves which give sensibility, &c.

Within the head and in the trunk we find also other parts.

33. The face presents several cavities, which serve to lodge the organs of sight, of smell, and of taste.

34. The cranium or skull is a sort of bony box, the interior of which is *filled* by one of the most important organs of the

29. In the animals at present referred to, how do the members exist? How are they distinguished? Have all animals the same number of members or limbs?

30. What is the skin? How is it secured? What is its form? What is the skeleton?

31. Does every animal possess a skeleton? What animals are without a skeleton? Is there any instance where the skin takes its place? What classes of animals have skeletons?

32. What are muscles? What is their function? What are placed between the muscles?

33. For what purpose are the several cavities in the face?

34. What is the cranium or Skull? What does it contain? Is it full? What is the continuation of the brain called? What is found on each side of the Skull?

body, the brain, which is continued downward in a thick, whitish cord, called the spinal marrow. It descends along the back and communicates with the principal nerves of the body. (*plate* 5, *fig.* 1.) On each side of the skull we find a small and very complicated apparatus, which is the seat of the organ of hearing.

35. In cutting through the ribs and opening the bony cage, which anatomists call the *thorax*, and which we commonly call the chest, or breast, we find the heart and lungs (*plate* 1, *fig.* 1.) A fleshy partition, *the diaphragm*, separates the chest from the belly or *abdomen*, and, in this latter cavity, are contained the stomach, the intestines, the liver, the spleen, and many other organs of less importance.

36. These different organs fulfil very various functions; some, such as the mouth, the teeth, the stomach, the intestines, and the liver, serve digestion; others, such as the lungs, are designed for respiration; others again, the heart for example, distribute to all the organs matter necessary for their nourishment, and there are others again the use of which is to enable us to appreciate tastes, and smells, to hear sounds, to see what surrounds us, to feel what touches us, and to transport us from place to place.

37. These functions, in spite of their diversity, tend to two principal objects, and are consequently divided into two classes: *the functions of one class have for object the preservation of the life of the individual, and are therefore denominated*, FUNCTIONS OF NUTRITION; the others serve to place the animal *in relation with* all that surrounds him, and, *consequently, are called* FUNCTIONS OF RELATION.

38. The functions of nutrition, as their name implies, all serve *in imparting* nutrition *to* the animal, either in separating nutritive matter from the productions of the earth, in modifying this matter and in reducing it to a fluid or juice, *fit* to be admitted into the organs, or finally, by conveying into the substance of the organs this nourishing fluid, which, by its combination, insures their maintenance and favors their growth: Consequently, digestion, respiration and the circulation of the blood belong to this class of functions.

39. *The functions of relation* are all those which place the animal in relation with the other beings of nature; they are principally the faculties of feeling in different ways, and of moving.

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35. What is the thorax? What does it contain? What separates the thorax from the abdomen? What does the abdomen contain?

36. What is the use of these different organs?

37. What is the chief objects of all these various functions?

38. What is the object of the functions of nutrition?

39. What is the object of the functions of relation?

By the aid of these functions the animal is enabled to appreciate the form, the color, and the position of objects surrounding him; to hear the sounds which they make, to advance towards or retire from them, in a word, they serve to establish between him and the external world a variety of relations which are as numerous as they are useful.

40. The functions of nutrition are indispensable to the maintenance of life, and they are found, in a greater or less number, in all living or organized beings, and for this reason, they are called the *functions of organic life*, or of *vegetative life.*

41. The functions of relation, on the contrary, are in a measure accessary, and do not exist in all living beings; plants have them not; animals alone possess them, but, in losing them they do not necessarily cease to live; during a part of their existence they do not even exercise them, and this state of repose of the functions of relation, constitutes *sleep.*

42. In consequence of these functions being peculiar to animals, they are also called the *functions of animal life.*

After what has been said, it is very easy to state, in a very few words, the most important differences which exist between vegetables and animals.

43. Vegetables are beings constituted for living, with the power of nourishing and reproducing themselves.

44. Animals are beings whose conformation enables them to live, to be nourished, to reproduce themselves, to feel and to move.

The reader will now, easily comprehend the difference between *organized* beings, as plants and animals, and *inorganic* bodies, as rocks and minerals, which do not possess the power of *nourishing* and *reproducing* themselves, the first and most important effects of living organization, for without these effects, Death would speedily leave the earth destitute of both animals and plants.

In the history of the animal functions, we shall first consider those which belong to vegetative life, and which have nutrition for their object.

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40. Why are the functions of nutrition called the functions of organic life? Do the functions of nutrition exist in all organized beings?

41. Do the functions of relation belong to all living things? What is without them? When the functions of relation are suspended what is the state of the animal?

42. Why are these called functions of animal life?

43. What are vegetables?

44. What are animals?

LESSON II.

Functions of Nutrition—Nutrition of Organs—Proof of the existence of the nutritive movement—Coloring of bones—The blood is the principal agent of nutrition—use of the blood—study of this liquid—physical properties of the blood—red and white blood—Globules—Serum—coagulation—venous and arterial blood—Transformation of venous into arterial blood by the action of the air.

OF THE FUNCTIONS OF NUTRITION.

OF THE NUTRITIVE ACT.

1. NUTRITION *is the vital act by which the different parts of the bodies of organized beings renew the materials of which they are composed.*

2. To effect this renovation, the animal appropriates certain substances within his reach, which are adapted to this purpose, and these substances being introduced into the body and distributed to the different organs, are there retained and become constituent parts of them.

3. At the same time that the organs thus acquire new materials they lose others, which, having become old and useless, are in some way detached and expelled.

4. Thus, then, the new materials take the place of those which have been detached from the organ, so that its substance is, little by little, renewed.

5. When a living being thus incorporates with its organs more material than it loses, its volume augments, and of course its weight increases:—Thus, by the act of nutrition, the infant, which at birth weighed only five or six pounds, is found to have acquired, when it has reached the age of twenty-five years, more than a hundred weight, and a proportionate increase in size; but if the contrary be true, and the living being loses more material than it incorporates with its organs, it grows thin, as is often observed when the adult approaches extreme age; and when these two phenomena are in just equilibrium, its weight remains the same.

6. This nutritive act takes place in all living beings.

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1. What is nutrition?
2. How do animals renew the materials of which their bodies are composed?
3. Do the organs always retain the materials acquired?
4. Why is the size of the organs not increased by the constant accession of new materials?
5 When an organ receives more material than it loses, what is the consequence? When an organ loses more than it receives what happens?
6. Does the act of nutrition take place in all things?

7. Brute bodies, as stones and minerals are not nourished. The materials of which these are composed remain the same as long as they exist, and if their volume increasc it is simply by the juxta-position of substances of the same nature as their own.

8. But animals and plants on the contrary grow by *intus-susception*, that is to say, by the dcposite of new particles within their very substance.

9. The continual process of composition and decomposition which constitutes the nutritivc act, is not perceptible to our senses; but obscrvations have been made which remove all doubt of its existcnce, even in the bones, the hardcst and deepest seated parts of the body. An English surgeon, Belcher, eating of a pig which had been fed by a dyer, remarkcd that the bones of the animal were red, and attributing this peculiarity to thc colored substances which it had eaten, conceived an idea that analogous means might serve to render visiblc the effects of the nutritive act; he made experiments which, repeated by a number of learned men, were crowned with entire success.

10. After feeding animals on madder for a certain time, it is always found that thc bones are stained red by a deposite of this coloring matter in their substance; and after having thus fed an animal, and then suspcnding the use of the madder, it is found, after a certain period, that the rcd matter which must have been deposited in the substance of these organs, is no longer there, but has been, as we must conclude, ejected. Now, these facts may be explained by the continuous proccss of composition and decomposition, to which is given the name of nutrition.

11. This renovation of the constitutent materials of the body is indispensablc to the continuance of life: when it stops in an organ, that organ decays, and when it ceases throughout, death soon follows.

12. The nutrition of organised bodies is effected by the aid of a liquid which conveys into all the organs, the necessary materials for their sustenance, and which serves at the same time, to carry away from their substance those particles which are detached by the nutritive act, and destined to be expelled from the body. In plants, this liquid is the sap, and in animals it is the blood.

7. Are stones nourished? How do they increasc in size?

8. How do animals and plants grow in size?

9. Is the nutritive act perceptible to ourselves?

10. How was it proved?

11. What is the consequence if nutrition ceascs in an organ? If in all the organs?

12. How is the nutrition of organized bodies effected? What are the names of this liquid?

OF THE BLOOD.

13. *The Blood is the nutritive liquid of animals.*

14. It is this liquid which maintains life in the organs, and furnishes them with the materials of which they are composed.

15. The blood is the source of all the humors formed in the body; as the saliva, tears, bile, &c.

16. In man, and all animals resembling him in organization, the blood is red. In a great number of others, it is colourless, or of a slight yellow or lilach tint.

17. The animals which have *red blood*, are the mammalia, birds, reptiles, fish, and certain worms called "Annelides."

18. The animals with *white blood*, are the insects, the Arachnides, (that is spiders, and other animals resembling them,) the Crustacea, (a class of animals composed of crabs, lobsters, &c.) the molusca, (or animals resembling snails and oysters) and some others.

19. It is a vulgar error to suppose that flies have red blood in the head: when one of these animals is crushed we see, it is true, an effusion of reddish liquid, but this is not blood, and comes from the eyes of these little beings, whose blood, like that of all insects, is white.

20. Blood is more or less thick and opaque. When examined by a microscope we perceive that it is formed of two distinct parts, namely :—

1st. Of a yellowish, transparent liquid, called *Serum.*

2nd. Of a great number of solid particles of extremely small size which swim in the serum, and which are called the *globules of the blood.*

21. To these globules the blood is indebted for its red color. They are flattened and have a considerable resemblance to small pieces of money slightly drilled out in the middle. (*plate* 1. *fig.* 4.) Their form and size vary in different animals.

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13. What is blood?
14. What is the use of the blood?
15. What is the blood the source of?
16. What is the color of the blood?
17. What animals have red blood?
18. What animals have white blood?
19. Have flies red blood?
20. Is the blood transparent? Of how many parts is it composed? What are these parts called? What is serum? What are the globules of the blood?
21. Upon what does the red color of the blood depend? What is the form of the globules? Are the size and form of the globules the same in all animals?

22. In man, the dog, the horse, and all other animals of the class of mammalia, the globules of the blood are circular.

23. In birds, reptiles, and fish, the globules are of an oval form.

24. They are smallest in the mammalia and largest in reptiles and fish.

25. The blood of the mammalia and birds contains the greatest proportion of globules.

26. In animals with white blood, the globules are colourless, generally circular and very few in number.

27. In its ordinary state, the blood is always fluid, and the globules swim freely in the serum; but when drawn from the vessels which contain it and left to itself, it is not slow to congeal, and to present the phenomenon of *coagulation.*

28. When blood coagulates, the globules unite themselves together in a mass, and little by little separate from the serum, to form a clot more or less solid.

29. The blood contains all the materials necessary to the reparation and growth of the organs; consequently it furnishes to all parts the matter of which they are in need for their nourishment, and also imparts the excitement necessary to the maintenance of life.

30. To appreciate fully, the importance of the office filled by the blood in the bodies of living animals, it is only necessary to bleed one, and observe the effects of the operation.

31. When the flow of blood continues for a certain time, the animal falls into syncope, (fainting,) and if the bleeding be not arrested, all motion ceases in a few moments; respiration is stopped and life is no longer manifest by external sign. If the animal be left in this condition, reality soon takes the place of appearance, and death speedily follows. But if we inject into his veins, blood similar to that which he has lost,we see with antonishment this semblance of a corpse return to life; in proportion as ad-

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22. What is the form of the globules in the mammalia?

23. In what class of animals are the globules oval?

24. In what animals are they smallest? In what animals largest?

25. What animals have the greatest proportion of globules in the blood?

26. What is the form and color of the globules in white blooded animals?

27. What is the ordinary state of the blood? When drawn from the vessels and left to itself, what takes place?

28. When blood coagulates what takes place?

29. What does the blood contain? What other use has the blood besides that of nourishing the organs?

30. How can you show the importance of the blood to living animals?

31. How is an animal effected by bleeding? What is the effect of injecting blood into the veins of an animal that has been exhausted by bleeding?

ditional quantities of blood are introduced into the vessels, he revives more and more, and soon breathes freely, moves with facility, resumes his habitual gait and is completely re-established.

32. This operation, known under the name of transfusion, is certainly one of the most remarkable that has been performed, and proves, better than all we could say, the importance of the action of the globules of the blood upon the living organs; for if we make use of serum, that is blood deprived of its globules, in the same manner, we produce no more effect than if we had used pure water, and death is not a less inevitable consequence of the hæmorrhage.

33. The influence of the blood upon the nutrition of the organs may be demonstrated with equal facility.

34. When by mechanical means we diminish, in an appreciable and permanent degree, the quantity of this fluid received by an organ, we perceive that it dwindles in size, and often even decays and becomes reduced to almost nothing.

35. On the other hand we observe, that the more any one part of the body is exercised, the greater the quantity of blood it receives, and the more it augments in volume. Indeed, every one knows that muscular exercise tends most to the developement of those parts which are the seat of it; that in dancers for example, the muscles of the legs, the calf in particular, acquire an extraordinary size, while with bakers and other men who perform hard labor with their arms, the superior members or extremities become more fleshy than any other parts. Now, the muscles receive more blood when in action than when in repose, and by this afflux of blood, the nutritive act of which they are the seat, is stimulated and their volume is increased.

36. The blood in giving nourishment to the organs, and in exciting the vital movement, undergoes a change; it is impoverished not only by the deposite of the particles which the organs appropriate to themselves, and incorporate with their substance, but also by receiving the old materials which are separated from the tissue of these same organs, and which, having become useless, or even injurious, have to be expelled from the body.

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32. What is the operation of injecting blood into the veins called? What does transfusion prove?

33. Does the blood influence the nutrition of the organs?

34. What is the effect of diminishing the quantity of blood received by an organ?

35. What effect does exercise produce on the different parts of the body? Why is the volume of the muscles increased when they are much exercised?

36. Does the blood undergo any change in nourishing the organs?

37. Consequently, there is a very great difference between the blood going to the organs, and that which has already passed through them, and which has contributed to their nourishment.

38. To the first is given the name of *arterial blood*, and to the second, the name of *venous blood*.

39. Arterial blood is of a vermillion red; it coagulates very easily and contains a large proportion of globules; and finally, it is essentially necessary to the maintenance of life.

40. Venous blood is of a blackish red color; it is less coagulable and less rich than the arterial blood, but what distinguishes it above every other quality, is, that after having passed through them, it is no longer capable of exciting the vital movement in the organs.

41. Notwithstanding, the blood thus vitiated does not cease to be useful, because it easily regains its vivifying qualities.

42. By action of the air, the venous blood is changed into arterial blood; it regains its vermillion color, and becomes again fit for the maintenance of life.

43. It is this transformation of venous blood into arterial blood, which constitutes the phenomenon of respiration.

LESSON III.

Functions of Nutrition—Circulation of the Blood—the Heart—Arteries—Veins—Motion of the blood in the bodies of the Mammiferæ—Mechanism of the circulation—Phenomenon of the pulse—Venous absorption—Secretion.

CIRCULATION OF THE BLOOD.

1. The blood does not remain at rest in the body; it is constantly passing through the organs which it nourishes, and returning to the respiratory apparatus to come in contact with the air, to be again distributed to the organs.

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37. Is the blood when it comes from an organ in the same condition as when it entered?

38. What is the blood called that goes to the organs? What is it called when it has left the organs?

39. What are the properties of arterial blood?

40. What are the properties of the venous blood? What is the essential quality that distinguishes venous from arterial blood?

41. Why does blood thus vitiated cease to be useful?

42. How is venous blood changed into arterial?

43. What does this transformation of venous into arterial blood constitute?

1. Is the blood at rest in the body?

2. *The continuous passage of the blood from the respiratory apparatus towards all the organs of the body, and the return of the blood from these organs to the apparatus of respiration, constitutes the phenomenon of the circulation.*

3. This liquid, as we have seen, moves continually in a sort of circle; after having traversed all the parts which it is destined to nourish, it returns to a particular organ to come in contact with the air, then goes back to the parts whence it came, passes through them, returns again to the apparatus of respiration, and so continues as long as life endures.

4. THE APPARATUS OF THE CIRCULATION, that is to say, the assemblage of organs destined to effect this conveyance or transportation of the blood, is composed:

FIRST. *Of canals, or pipes, in which the blood runs.*

SECOND. *Of the heart which serves to set it in motion.*

5. The *heart* is the centre of the apparatus of the circulation; it is a sort of fleshy pouch communicating with the blood vessels, which receiving the blood into its interior, and which, by contracting on itself from time to time, forces this fluid into the canals, and thus keeps up a continual current in them.

6. Almost all animals have a heart. This organ exists not only in the mammalia, birds, reptiles, and fish, but also in snails, oysters, and other animals of the class of mollusca; in crabs and lobsters; in spiders, &c.

7. The blood vessels are of two kinds, namely:

8. 1st. The *arteries* which carry the blood from the heart to all parts of the body.

9. 2nd. The *veins* which bring back this liquid from all parts of the body to the heart.

10. The arteries spring from the heart and divide into branches which *decrease in size*, and *increase in number* as they advance, and are distributed to the very numerous parts, distant from the heart.

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2. What constitutes the phenomenon of the circulation?

3. After having traversed all the parts it is destined to nourish, what becomes of the blood?

4. What is meant by the apparatus of the circulation? Of what parts is it composed?

5. What is a heart?

6. Have all animals a heart?

7. How many kinds of blood vessels are there?

8. What is the function of the arteries?

9. What is the function of the veins?

10. Where do the arteries take their rise? How are they distributed?

11. The veins present a similar disposition, but which is designed to produce an entirely opposite result, because the blood in these vessels pursues an inverse course. They are very numerous at a distance from the heart, but little by little they unite to form larger canals which, in turn, again unite so that they terminate at the heart, in only one or two large trunks.

12. The ultimate ramifications of the arteries in the substance of the organs, are continued into the radicles of the veins, so as to form a series of uninterrupted and narrow canals by which the blood passes through the organs.

13. To these delicate canals, which establish the communication between the termination of the arteries and the beginning of the veins, is applied the name of *capillary* vessels. (*plate* 2. *fig.* 2.) This name has been given to them in consideration of their extreme fineness, which makes them comparable to hairs.

14. At the extremity opposite to that where we find the capillary vessels, the arteries and veins also communicate with each other by the intervention of the cavities of the heart.

15. The result of this arrangement is, that the vascular apparatus forms a complete circle in which the blood moves, constantly returning to its point of departure.

16. The circulating circle may be compared to a tree, the trunk of which is doubled upon itself, so as to cause the ultimate ramifications of the branches to meet the ultimate divisions of the roots; the upper portion of the trunk and the roots would represent the veins.

17. In all those animals which most resemble man, (anatomically) such as the monkey, the dog, horse, ox, &c., the *heart* is placed, between the two lungs, in the cavity of the chest, which anatomists call the thorax—(*plate* 1, *fig.* 1 *and fig.* 6.)

18. The general form of the heart is that of an inverted cone, the apex down and a little to the left.

19. This organ is enveloped in a double, membranous sac called *pericardium*, and is suspended in the pericardium by the vessels

11. How are the veins arranged?

12. How do the ultimate ramifications of the arteries terminate?

13. What are the capillary vessels? Why are they so called?

14. Have the arteries and veins any other communication than by the capillary vessels?

15. What is the result of the arrangement of the heart and blood vessels as described?

16. To what may we compare the circulating circle?

17. What is the situation of the heart?

18. What is the form of the heart?

19. Has the heart any covering proper to it? How is it suspended in the pericardium? Does the heart adhere to the surrounding parts?

which arise from its superior and enlarged extremity; but it does not adhere in any other point of its surface to the neighbouring parts.

20. The substance of the heart is almost entirely fleshy: it is a hollow muscle the cavity of which communicates with the arteries and veins.

21. In man and all the mammalia, as well as birds, it has four distinct cavities. A thick, vertical partition divides it into two halves, each one forming two cavities, one above the other; a *ventricle* and an *auricle.* (*plate* 1, *fig.* 2.)

22. The two ventricles occupy the inferior part of the heart, and do not communicate with each other, but each one opens into the auricle above it.

23. The cavities of the left side of the heart contain arterial blood, and those of the right side, venous blood.

24. The vessels which convey arterial blood into all the organs, take their origin from the left ventricle of the heart through the medium of a single trunk called the *aorta.* (*plate* 1, *fig.* 1; *and plate* 2, *fig* 1.)

25. This great artery first mounts upwards towards the base of the neck, then bends downwards, forming a sort of crook, passes behind the heart and descends vertically, in front of the spine, to the lower part of the belly. In its course, the aorta gives off a great number of branches, the principal of which are:

26. 1st. The two *carotid arteries* mount along the sides of the neck and supply the head with blood; (*plate* 1 *fig.* 1, *a a*, *and plate* 2 *fig.* 1 *a.*

27. 2nd. The two arteries of the upper extremities which successively obtain the names of *sub-clavian, axillary* and *brachial* arteries, as they pass under the clavicle, or cross the armpit, or descend along the arm to the elbow, where they divide into two branches, called the *radial* and *ulnar* or *cubital* arteries;

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20. What is the substance of the heart? Is the heart solid?

21. How many cavities has the heart? How is it divided? What are the cavities of the heart called?

22. What part of the heart is occupied by the ventricles? Do the ventricles communicate with each other? Do they communicate with the auricles? How is the auricle situated in regard to the ventricle?

23. What kind of blood is contained in the cavities of the left side of the heart? In which side of the heart is found the venous blood?

24. From what part of the heart do those vessels arise which carry arterial blood? What is the name of the great arterial trunk as it arises from the heart?

25. Describe the course of the Aorta?

26. What is the course of and distribution of the carotid arteries?

27. What arteries supply the upper extremities?

28. 3rd. The *intercostal arteries* are several in number, and run between the ribs on each side of the body;

29. 4th. The *cœliac* artery, which is distributed to the stomach, the liver, and the spleen;

30. 5th. The *mesentric* arteries, which ramify upon the intestines;

31. 6th. The *renal* arteries which penetrate into the kidneys;

32. And 7th. The *iliac* arteries, which in a manner terminate the *aorta*, and which convey blood to the lower extremities, descend along the thighs and are there called femoral arteries; then they divide into many branches which terminate in the feet.

33. The *veins*, which receive the blood thus transmitted to all parts of the body, follow very nearly the same course as the arteries; but they are larger, more numerous and generally situated more superficially. A great number of these vessels pass beneath the skin, others accompany the arteries, and, at last, they all unite to form two great trunks which empty into the right auricle of the heart, and which have received the names of *vena cava superior* and *vena cava inferior*. (*Plate* 1. *fig.* 1. *and* 2.)

34. The veins which come from the intestines present an important peculiarity. After uniting in a large trunk, they penetrate the liver, and there ramify like the arteries; there they again unite into a trunk and terminate in the inferior vena cava close to the heart. This arrangement of the vessels is called the *system of the vena porta.*

35. The venous blood, poured by the *venæ cavæ* into the right auricle of the heart, descends from it into the ventricle of the same side.

36. The right ventricle of the heart gives rise to a large artery, called the *pulmonary artery*, which next receives this same blood, and carries it into the lungs. (*Plate* 1. *fi.* 1 *and* 2, *a. p.*)

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28. What arteries run between the ribs?

29. What is the distribution of the Cœliac artery?

30. What arteries ramify upon the intestines?

31. What is the distribution of the renal arteries?

32. What arteries are distributed to the lower extremities?

33. What is the general course of the veins? In what respect do the veins differ from the arteries generally? Where do the great venous trunks empty? What are they called?

34. What is the peculiar arrangement of the veins coming from the intestines? What is it called?

35. What becomes of the venous blood after entering the right auricle of the heart?

36. What artery arises from the right ventricle? Into what part does the pulmonary artery carry the blood?

37. This vessel divides into two branches, one going to the right and the other to the left, to enter the two corresponding lungs, and are divided into almost an infinity of branches, which are spread over the surface of the little membranous cells of these organs.

38. The capillary vessels by which the pulmonary arteries terminate, give rise to veins, which unite together and finally form too large vessels, called *pulmonary veins*, which empty into the left auricle of the heart. (*Plate* 1, *fig*. 1 *and* 2, *v. p.*)

39. Consequently, the pulmonary veins receive the venous blood, which was brought to the lungs by the pulmonary artery, and which has now become arterial, by the effect produced on it, by contact with the air in the interior of these organs; they carry it back again to the heart and pour it into the left auricle.

40. Finally, from the left auricle this fluid descends into the left ventricle, whence we have already seen it issue to be distributed to the different parts of the body, through the medium of the aorta and its branches.

To recapitulate what has just been said, on the route pursued by the blood, in the apparatus of the circulation in mammiferous animals and birds, we see:

41. 1st. That the venous blood arrives from all parts of the body by the general system of veins;

2d. That from these veins it enters the right auricle of the heart;

3rd. That from the right auricle it passes into the right ventricle;

4th. That from the right ventricle the venous blood passes through the pulmonary artery to the lungs;

5th. That in the capillary vessels, which form the termination of the pulmonary artery, and commencement of the pulmonary veins, this liquid is changed into arterial blood;

6th. That this arterial blood returns from the lungs, through the pulmonary veins, and enters the left auricle of the heart;

7th. That from the left auricle it descends into the ventricle of the same side;

8th. That from the left ventricle it is forced into the aorta, by which it is distributed to all parts of the body.

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37. What is the distribution of the pulmonary artery?
38. What is the origin of the pulmonary veins? Where do they empty?
39. What kind of blood do the pulmonary veins convey to the heart? How is the venous, changed into arterial blood?
40. What becomes of the blood after it enters the left auricle?
41. What is the route pursued by the blood in the apparatus of the circulation?

42. And 9th.—and finally, that in the capillary terminations of the system of canals formed by the aorta, the arterial blood acts upon the organs, is changed there into *venous* blood, and enters the veins to be carried again to the heart.

43. In accomplishing the circulatory circle, the blood then passes twice through the heart, in the state of venous blood on the right side, and in the state of arterial blood in the left side of this organ; (*Plate* 1, *fig*. 2, *and plate* 2, *fig* 2.) yet, the circulation is complete, because the pulmonary and aortic cavities of the heart do not open one into the other, and the venous blood passes through the entire respiratory apparatus to be transmuted into arterial blood.

44. The mechanism by which the blood moves through these vessels is easily understood. The cavities of the heart contract and enlarge alternately, and by contracting they force the blood into the canals with which they (the cavities) are in communication.

45. The two ventricles contract at the same time, and while their sides or parietes relax, the auricles in their turn contract.

46. The movement of contraction bears the name of *systole* and the term *diastole* is applied to the opposite movement, or dilatation.

47. The beating or pulsation of the heart is very frequent; in man of adult age it takes place from sixty to seventy-five times in a minute; in old men the number of beats is a little increased, and in very young infants it is generally about one hundred and twenty. But a variety of circumstances may influence both the frequency and force of the beats of the heart; they are accellerated by exercise, by moral emotions, and by a great number of diseases; in swooning or syncope, they are considerably diminished, or even completely interrupted.

48. The left ventricle in dilating fills with blood, and in contracting afterwards, forces out the liquid which it contains.

49. This ventricle communicates only with the left auricle by an opening called the *auriculo-ventricular* opening, and with the

42. Where is the arterial changed into venous blood?

43. In accomplishing its entire circle, how many times does the blood pass through the heart?

44. What causes the blood to move in the blood vessels?

45. Do the auricles and ventricles of the heart contract at the same time?

46. What is the contraction of the heart called? What is its dilation called?

47. What is the frequency of the heart's pulsation? Is it most frequent in infants or in old men? What circumstances influence the frequency of the heart's pulsation?

48. When the left ventricle dilates, what happens?

49. With what does the left ventricle communicate?

aorta; (*plate* 1. *fig.* 2, *s.*) the blood, at the moment of its contraction must then either flow back into the auricle, or enter the aorta.

50. Now, around the edges of this *auriculo-ventricular* opening, there is placed a sort of valve, called the *mitral valve*, which is so arranged as to rise up and close this opening when it is pushed from below upwards, (*plate* 1. *fig* 3.) From this construction, it happens, that when the blood tends towards entering into the auricle, the *mitral valve* is pushed up and interrupts the communication between the auricle and ventricle.

51. Therefore, when the left ventricle contracts, the blood finds no other outlet than the aorta, and enters this vessel which it distends with more or less force, for its parietes, as well as those of all the arteries, are very elastic.

52. Other valves situated at the entrance of the aorta, prevent the blood from returning into the left ventricle, so that, pressed by the elastic force of the arterial parietes, it is continually pushed forward, from the heart towards the extremities of the arteries.

53. The phenomenon known under the name of the *pulse*, is nothing else than the motion caused by the pressure of the blood against the parietes of the arteries every time that the heart contracts. According to the frequency and force of these motions, we may judge of the manner in which the organ beats, and draw therefrom, deductions useful in medicine. But the pulse is not felt in all parts; to perceive it, we must slightly compress an artery of a certain volume between the finger and a resisting surface, of a bone for example, and select a vessel situated near the skin, as the radial artery at the wrist.

54. The impulsion received by the blood at its exit from the left ventricle of the heart, is communicated to the capillary vessels and to the veins, and determines the progression of the blood in them. But there are other circumstances which favor the return of the venous blood towards the right ventricle; such as the presence of valves in the interior of the veins. (*plate* 1. *fig.* 3.)

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50. Where is the mitral valve placed? What is the use of the mitral valve?

51. Into what part is the blood forced by the contraction of the left ventricle? Why does it not not go back into the auricle?

52. What prevents the blood from returning into the left ventricle from the aorta? Are the arteries elastic or not?

53. What is the pulse? Is the pulse felt in all parts? What does the pulse indicate? What circumstances are to be observed in order to feel the pulse?

54. What causes the blood to circulate in the capillary vessels? What other circumstance, besides the impulsion received from the heart, favors the return of the blood towards the right ventricle?

55. The passage of the blood through the right cavities of the heart, is effected in the same manner as in the left cavities. Between the right auricle and right ventricle there also exists a valve, called the ***tricusped valve***, which prevents the blood from returning from the ventricle into the auricle, (*plate* 2, *o. and fig.* 3.) and by the contractions of this ventricle the blood is forced to circulate in the vessels of the lungs and to arrive at the left auricle.

56. It is the ventricles, as we have seen, which force the blood into the arteries and cause it to circulate.

57. The auricles are a sort of reservoirs, designed to contain the blood arriving by the veins, and to pour it into the corresponding ventricles.

58. Such is the march of the blood, not only in man and all the mammalia, but also in birds; in the sequel we shall see that in reptiles and in fish, the structure of the heart is less complicated, and that the blood follows a somewhat different direction.

OF ABSORPTION.

59. The blood, in passing through the veins from their capillary origin in the substance of the organs to their termination in the right auricle of the heart, carries with it all the fluids which in some way filter through the parietes of these vessels. Fluid substances which may be in contact with the surface of the body and of the great hollow cavities in its interior, or which are deposited in the depth of the organs, are, as it were, pumped up more, or less rapidly, and carried into the torrent of the circulation.

60. ***To the passage of substances, of whatever kind, from the exterior, into the interior of the blood vessels through their parietes or particular canals, and their mixture with the blood,*** is given the name of ABSORPTION.

61. Substances thus absorbed, generally, penetrate directly into the veins; but under some circumstances they are carried thither by particular canals, called *lymphatic vessels.* In describing the act of digestion, we shall have occasion to refer again to these vessels.

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55. How is the passage of the blood through the right side of the heart effected? What valve exists between the right auricle, and right ventricle? How is the blood forced to circulate through the lungs?

56. What forces the blood into the arteries?

57. What are the auricles?

58. Is the structure of the heart, and the circulation the same in all animals?

59. Do substances different from the blood enter into the circulation?

60. What is absorption?

61. Is absorption effected by the veins only?

62. All parts of the body may be the seat of a more or less rapid absorption; it is by this phenomenon that liquids, introduced into the stomach are found, a very short time afterwards, mingled with the venous blood, and that certain vapors, mixed with the air drawn into the lungs, sometimes act upon remote parts of the body, such as the brain, as happens when we breathe alcoholic vapors. It is also by absortion alone, that we can explain how poisons applied to the lips, the eye, or to a slight erosion of the skin, penetrate into the interior of the body, and cause death, often with as much rapidity as if they had been conveyed directly into the stomach.

63. It is by the absorption, which takes place in the substance of all the organs, that the old materials no longer of use and separated from the living tissues by the nutritive act, are poured into the circulating torrent to be carried out of the body.

OF EXHALATION AND OF SECRETION.

64. The blood, in circulating through the body, is not limited to the nutrition of the organs through which it passes, and to mingling with it absorbed matters; on passing into certain parts of the body, it abandons a portion of the matters which it contains, and in this way gives birth to peculiar liquids called *humors*.

65. This separation of the contained matters from the blood may take place in two ways: by exhalation and by secretion.

66. Exhalation *is the separation of a portion of the most aqueous part of the blood, which, in some manner, filters through the parietes of the vessels.*

67. The exhaled liquids do not differ much from serum, except that they contain more water. Sometimes they accumulate in the internal cavities of the body; at others they are diffused over the surface and are evaported into the air. It is in this way that a considerable quantity of vapor escapes from the lungs, and a very active evaporation takes place upon the surface of the skin.

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62. Does absorption take place in all parts of the body?

63. By what process are those materials which are no longer of use, carried out of the body?

64. Is the office of the blood limited to the nutrition of the organs through which it passes?

65. In how many ways may matters contained in the blood be separated from it?

66. What is exhalation?

67. What is the nature of the liquid exhaled? What becomes of the exhalations?

68. Secretion *is the production of certain liquids which resemble the serum in nothing, and which are also formed at the expense of the blood.*

69. Tears, saliva, bile, urine, &c., are liquids, secreted in this way.

70. The phenomenon of secretion always takes plaee in particular organs. Sometimes it is seated in the follicles, and sometimes in the glands.

71. The *follicles* are very small pouches whieh are strewed through substanee of the membranes, and which open upon their surfaee, by small pores.

72. The *follicles* of the skin seerete the sweat; those on the edge of the eye-lids whieh seerete the yellow matter which sometimes aeeumulates during sleep, are organs of this kind.

73. The *glands* are more voluminous organs, eomposed of small granulations united in a eompaet and distinct mass. These granulations are the seat of seeretion, and they generally communieate externally, by small tubes or conduits, which, uniting together like the roots of a tree, finally form an excretory eanal by which the seereted liquid is poured out.

74. The salivary glands whieh secrete the saliva, the laehrymal glands, whieh secrete the tears, and the liver whieh secretes the bile, are organs of this elass.

75. The aet of seeretion is not designed simply to produee liquids useful in the exercise of eertain funetions, sueh as the saliva and bile; but also to free the blood from the old materials, separated from the tissue of the organs by the aet of nutrition, and other useless or injurious matters, whieh may beeome mixed with it by the effect of absorption. The seeretion of urine, whieh takes plaee in the kidneys, (situated in the abdomen, one on each side of the spine) and the expulsion of it whieh follows, is the principal means by whieh this sort of purification of the blood is effeeted.

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68. What is secretion?
69. Give examples of the secretions?
70. In what part does the secretion take place?
71. What are follicles?
72. How is the sweat produced?
73. What are glands? How do they communicate externally?
74. Give example of secreting glands?
75. What are the objects of secretion? What organs secrete the urine?

LESSON IV.

Functions of Nutrition—*Respiration—Necessity of contact with the air—Asphyxia—Composition of the atmosphere—Principal phenomena of respiration—the Lungs—Mechanism of respiration—Animal Heat.*

OF RESPIRATION.

We have already seen that the arterial blood, by its action upon the living tissues, loses those qualities which make it fit for the support of animal life, and after having been in this way viciated, it regains its first properties by contact with the air.

1. *The transformation of venous into arterial blood, by the action of the air, constitutes the phenomenon of* Respiration.

2. Respiration, and consequently contact with the air, is indispensable to all living beings; plants as well as animals feel the want of it, and when deprived of it, both very soon perish.

3. When, from any cause whatever, respiration is arrested, all the animal functions are disturbed. Life soon ceases to be manifest; the animal falls into a state of *asphyxia* or apparent death, and in a very short time life becomes entirely extinct.

4. At first sight, we might believe that animals which live in the depths of the waters, as fish, are removed from the influence of the air, and consequently form an exception to the law of which we have spoken; but it is not so, for the liquid in which they dwell, absorbs and holds in solution a certain quantity of air which may be easily separated from it, and which is sufficient for the support of life in them; it is impossible for them to exist in water deprived of its air, and they are seen to become asphyxiated, and die, just as the mammiferæ and birds do, when excluded from the action of the atmospheric air under its ordinary form.

5. In man and in the other mammalia the apparatus of respiration consists:

1st. Of the lungs, organs which are the seat of this function;

2nd. Of canals, by which the air from without is conveyed into the lungs;

3rd. Of organs which effect the entrance of the air into this apparatus, and which afterwards expel it, to make room for fresh supplies of this fluid.

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1. What constitutes the phenomenon of respiration?
2. Is contact with the air necessary to all living beings?
3. If respiration be arrested what is the consequence?
4. Do fish require contact with the air?
5. What parts compose the apparatus of respiration?

6. The *lungs* (*plate* 1, *fig*, 1 *and* 7) are very elastic, spongy organs, contained in the cavity of the chest, and formed by the union of a great number of membranous vesicles, resembling little cells, which generally communicate one with another. Into these vesicles is introduced the external air: when it penetrates their cavities it distends them and thus augments the entire volume of the lung, which happens in *inspiration;* on the contrary when the lungs are emptied of the air which distends them, their volume diminishes, as happens in *expiration.*

7. The lungs communicate with the external air by a long canal which is terminated by the mouth and nose.

8. The air, to reach these organs, passes through the nasal fossæ or nostrils, or through the mouth into the *pharynx*, then enters into the *larynx*, descends along the *trachea* and is distributed to the pulmonary cells by other canals or tubes called bronchiæ. (*plate* 1 *fig.* 7—*and plate* 3 *fig.* 1.)

9. The nasal fossæ and the mouth terminate internally in the *pharynx*, so that the supply of air necessary for respiration may reach this cavity by either route.

10. At the bottom of the pharynx or swallow, we find an opening called the *glottis* which leads into the *larynx*, and permits the air to enter therein.

11. The *larynx* is a short tube of considerable diameter, situated at the superior and anterior part of the neck, and which contributes to the production of the voice.

12. The *larynx* is prolonged inferiorly into a long tube, called the *trachea* or wind pipe, which descends through the neck and enters into the thorax. This tube is formed by a series of cartilagenous rings, and is lined internally by a thin membrane, which also lines the larynx, and is continuous with that of the pharynx. The cartilagenous rings of the trachea are very elastic, and prevent this air canal from being effaced, and thus offer an obstacle to the passage of the air.

13. At its lower extremity, the trachea is divided into two branches, one going to each of the two lungs; they are called *bronchiæ.*

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6. What are the lungs?
7. How do the lungs communicate with the external air?
8. How does the air reach the lungs?
9. How do the nostrils terminate internally?
10. To what part does the glottis lead?
11. What is the larynx?
12. What is the trachea? What is is its structure?
13. What are the bronchiæ?

14. Soon after they enter the lungs, these bronchiæ are subdivided, and ramify in an almost infinity of branches, so as to furnish every pulmonary cell with a little branch, which opens into it, and conveys there the air necessary to respiration.

15. The instrument which causes the air to pass through these tubes, and to enter the lungs, or to go out from them is the *thorax*. (*Plate* 1. *fig*. 5 *and* 6.)

16. The mechanism by which this phenomenon is produced, is very simple, and in almost every respect resembles the play of a pair of bellows, except that the air escapes by the same passage that it entered the lungs, which is not the case in the bellows.

17. The lungs are lodged in a great cavity, called the chest, or *thorax*, the sides of which are moveable, and so arranged as to enlarge and diminish the size of the cavity alternately; the lungs follow these motions and dilate, and contract in consequence; now, in the first case, (when the thorax dilates) the air, pressed by all the weight of the surrounding atmosphere, is precipitated into the chest, through the mouth or nostrils, and trachea and fills the pulmonary cells, in the same way that water mounts in the body of a pump when the piston is raised. In the second case, (in the act of expiration) the air contained in the lungs, is, on the contrary, compressed and partialy escapes by the route which served it for entrance.

18. The cavity of the *thorax*, (*plate* 1. *fig*. 5, *and* 6.) is formed principally by the ribs which are attached, posteriorly, to the spine or vertebral column, and in front to the bone of the *sternum*; the spaces which exist between the ribs are filled up by muscles, and below, this species of chamber is separated from the belly by a fleshy partition called the *diaphragm*.

19. The enlargement of the chest, or inspiration is produced in two ways; 1st. by the elevation of the ribs; 2nd. by the muscular contraction of the *diaphragm*, which, in a state of repose rises into the chest in the form of an arch, and which in contracting is lowered down.

20. We have seen that it is by the nose or mouth, the pharynx, the larynx, the trachea, and the bronchiæ that the air enters into

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14. How do the bronchiæ terminate?
15. What causes the air to pass through the lungs?
16. To what is this mechanism comparable?
17. Where are the lungs situated? What happens when the thorax dilates? How does the air escape from the lungs?
18. How is the cavity of the thorax formed? What separates it from the belly?
19. How is inspiration produced?
20. How does the air act upon the blood?

the lungs. The venous blood, which is to be subjected to the salutary influence of this air, arrives, at the same time, in the little vessels, which ramify in every direction over the sides of the cells; consequently, it is through the very sides of these capillary vessels that the air acts upon this fluid.

21. The blood coming to the lungs is of a blackish red color, and is not fit to support life in the organs; but so soon as it comes in contact with the air it changes its nature; its color becomes of a bright red, regains its vivifying properties and acquires all the characteristics of arterial blood.

22. The atmospheric air which thus enters into the lungs, and there produces so remarkable a phenomenon, is chiefly composed of two substances which differ very much from each other; namely *oxygen*, and *azote* or *nitrogen.*

23. Though the oxygen which enters into the composition of the air forms but about one fifth (21 parts in the 100,) it is its most important part. It is to the oxygen that the air owes its property of supporting life, and of sustaining the burning of combustible bodies when inflamed.

24. *Azote, or Nitrogen,* which enters into the composition of the air in the proportion of 79 parts in a 100, is unfit for respiration, and incapable of supporting combustion. It seems to serve only to dilute the oxygen, and thus mitigate the otherwise too irritating action of this gas.

25. By being breathed the air changes its nature; its oxygen disappears little by little, and is replaced by another fluid called *carbonic acid gas.*

26. This *carbonic acid gas* is composed of oxygen combined with *carbon,* derived from the blood; instead of being fit to support life, it acts as a poison on animals that breathe it for a short time, and causes death.

27. On this account, by the respiration of animals, the air is gradually vitiated, and, if it were not renewed, would soon occasion asphyxia.

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21. What is the color of the blood when it enters the lungs? What change does contact with the air produce upon it?

22. Of what is atmospheric air composed?

23. What is the proportion of oxygen in the air? What is the great use of the oxygen?

24. What is the proportion of nitrogen in the air? Is it capable of supporting animal life? What seems to be its use?

25. What effect is produced upon the air by breathing it?

26. Of what is carbonic acid gas composed? Whence is the carbon derived? How does it act on those animals that breathe it?

27. What would happen if the air breathed by animals were not renewed?

28. [Carbonic acid gas, which extinguishes bodies in combustion in the same way as azote, is formed by the combustion of charcoal; also, during the fermentation of wine, and of beer, which makes it sparkling and frothy.

29. It is upon the action of this gas on the animal economy that the asphyxia, produced by the vapor of charcoal, depends, as well as the greater number of accidents of the same sort which occur in mines, caves, wells, and vats wherein wine or beer are fermenting. In a grotto near Naples, this gas is continuously disengaged from the earth, and gives rise to phenomena, which, at first sight, appear very singular, and excite the admiration of the traveller; when a man enters this cavern he experiences no inconvenience in his respiration ; but a dog following him very soon falls down in a state of asphyxia at his feet, and would soon expire, were he not speedily removed to the pure air. This arises from the fact that the carbonic acid gas being much heavier than the air, sinks down and forms upon the bottom of the cave a bed or stratum of about two feet thick. Now, a dog that enters the grotto is necessarily plunged over his head into this memphytic gas, and must necessarily become asphyxiate, while a man who is very much taller, only has the lower part of his body exposed to the action of the carbonic acid, and breathes freely the air which floats above. This remarable place is known under the name of the *Grotto del Cano, or dog's grotto.*]

30. The air which escapes from the lungs is composed of the nitrogen inspired, of a portion of oxygen not employed, and of carbonic acid furnished by the act of respiration.

31. The expired air is also loaded with vapor of water exhaled from the blood during its passage through the capillary vessels of the lungs. This vapor becomes very perceptible, when the cold condenses it, at the moment of its issue from the body, and constitutes what physiologists call *pulmonary transpiration.*

32. Since the air is quickly vitiated by respiration, and its oxygen disappears to be replaced by the carbonic acid, we readily infer, that this fluid must be constantly renewed in the lungs, and in fact that this takes place in consequence of the alternate movements of inspiration and expiration.

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28. How is carbonic acid gas formed?

29. Upon what do certain accidents in mines, caves, wells, &c. depend? What is the *Grotto del Cano* near Naples remarkable for?

30. Of what is the air which escapes from the lungs composed?

31. What is pulmonary transpiration?

32. Why is it necessary te renew the air in the lungs?

33. We are informed of the degree of alteration which the air has undergone in our lungs, by the sensation which induces us to renew it. This sensation, scarcely appreciable in ordinary respiration, because we hasten to comply with the necessity of frequently renewing the air, becomes painful if not promptly satisfied; and is sometimes accompanied by anxiety, and even agony; an instructive warning of the imperious necessity of respiration.

34. In man there is commonly twenty inspirations per minute.

35. In all the mammalia, in birds, and in reptiles, respiration takes place in lungs, and very nearly in the same manner as in man.

36. In the greater number of aquatic animals, such as fish, lobsters, oysters, &c., it is altogether different, and respiration takes place through the medium of a sort of membraneous fringes called *branchiæ;* we shall recur to this in the sequel.

37. The air necessary to the support of life in insects, penetrates into all parts of their bodies through particular canals called *tracheæ.*

38. Finally; there are some animals which have neither *lungs* nor *branchiæ*, nor *tracheæ*, in which respiration is accomplished by the surface of the skin. The earth-worm is an example of this kind.

OF ANIMAL HEAT.

39. The greater number of animals appear cold when we touch them, and indeed, the temperature of their bodies is not much above that of the atmosphere, and changes with it. In man, and other animals that approach him in their organization, it is otherwise; they have the faculty of producing a sufficient quantity of caloric to maintain their temperatures, nearly always at the same degree, under all atmospheric changes, and keep themselves warm.

40. We designate under the name of *cold blooded animals*, all those whose proper heat is not very perceivable, and call those *warm blooded animals* which produce sufficient heat independently of the atmosphere surrounding them.

33. How are we made acquainted with the alteration the air has undergone in the lungs?

34. How many times does a man respire in a minute?

35. Does respiration take place in lungs in all animals?

36. In what organs does respiration take place in aquatic animals?

37. How does air enter the bodies of insects?

38. How does respiration take place in those animals which have neither lungs, nor branchiæ, nor tracheæ?

39. Are all animals of the same temperature?

40. What is meant by cold blooded animals? What is meant by warm blooded animals?

41. The production of this heat, which is called *animal heat*, seems to depend upon the act of respiration.

42. The combination of the oxygen of the air with the venous blood, in the interior of the lungs, as we have already seen, causes the formation of a certain quantity of carbonic acid gas, in the same manner as in the case where oxygen combines with carbon, in producing the phenomenon of combustion, and, in both instances, must extricate a greater or less quantity of heat.

43. The faculty of thus producing heat, is common to all animals; but the greater part of them develope it in so small a degree that it is not appreciable by our ordinary thermometers, while in others, it is so great that we do not require physical instruments to ascertain its existence.

44. The only warm blooded animals are the mammalia and birds; all the rest are cold blooded.

45. The temperature of the body of man, is about 101 degrees of Fahrenheit. It is about the same in the other mammalia, but birds produce more heat, their temperature rising to about 108° Fahrenheit.

LESSON V.

FUNCTIONS OF NUTRITION—*Digestion—Mouth—The prehension of aliments—Mastication—Teeth—Their structure—The manner of their formation—Their form and use—Saliva—Salivary glands—Deglutition—Pharynx—Œsophagus.*

1. The blood, as we have seen, in nourishing all the organs, it may be said, loses somewhat of its properties, and requires to retrieve the losses which it thus undergoes; now, it is renewed by receiving new materials from the productions of the earth.

2. These materials, destined to the support of the blood, and consequently to the support of the whole body, are furnished by the various *aliments* or food.

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41. Upon what does the production of animal heat depend?
42. How is animal heat produced?
43. Is the faculty of producing heat common to all animals?
44. What animals are warm blooded?
45. What is the temperature of the body of man? What is the temperature of birds?

1. How does the blood regain those properties which it loses by nourishing the organs?
2. What furnishes the materials for the support of the blood?

3. That they may be nourished, all living beings require that alimentary substance should be introduced into their bodies from time to time.

4. Plants pump up by their roots the aliments furnished them by the earth, and these matters are mingled with the nutritious liquid called *sap*, which permiates throughout their tissues without having undergone any preparation.

5. With animals it is altogether different. The aliments, previously to being absorbed and diffused through the different parts of the body, to afford nourishment to the organs, and to enter into the composition of their tissues, have to undergo a certain process of preparation, called *digestion.*

6. Digestion has for its object:

1st. To separate from alimentary substances the nutritive part from that which is not.

2nd. To transform this nutritive part into a peculiar liquid, fit to mix with the blood and nourish the organs, which liquid is called *chyle.*

7. The process of digestion always takes place in a cavity situated in the interior of the body and communicating externally in such a way that aliments may enter it.

8. All animals are provided with a *digestive cavity.*

9. Plants, on the contrary, having no need to digest aliments, have no such cavity. [The alimentary surface of a plant is the exterior of its root spread out in the earth.]

10. In some animals the digestive cavity is simply a pouch, communicating externally by a single opening, which performs the functions both of a mouth and of an anus.

11. But with the greatest number it is otherwise. The digestive cavity has the form of a tube, open at its two ends and enlarged about the middle. This enlarged portion of the digestive tube is named *stomach*, and serves to contain the aliments, while the greatest part of the process of digestion is performed.

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3. That living beings may be nourished, what circumstance is necessary?

4. Do the nutritious fluids, received by plants from the earth, undergo any process of preparation or digestion?

5. In order to nourish animal organs, is it sufficient to introduce food into the stomach?

6. What is the object of digestion? What is chyle?

7. Where does digestion take place?

8. Have all animals a digestive cavity?

9. Why have plants no digestive cavity?

10. What is the nature of the digestive cavity in some animals?

11. What is the form of the digestive cavity in the greatest number of animals? What part is called the stomach?

12. The superior opening of this tube is the *mouth;* it is through it that food enters the digestive cavity. The inferior opening, called *anus*, is destined as an outlet to matters unfit for nutrition, which are separated from the food by digestion.

13. In quadrupeds and most other animals, we distinguish, in this alimentary tube, diverse portions, the uses of which are different; they are:

1st. The mouth.
2nd. The pharynx or swallow.
3rd. The Œsophagus.
4th. The Stomach.
5th. The Intestine.

14. Other organs, or instruments, also concur to effect the digestion of food, and constitute, with the tube of which we have just spoken, the digestive apparatus; the principal are:

1st. The teeth destined to divide and grind the food.

2nd. Certain glands, such as the liver and salivary glands, serve to form the humors, which act upon the food in order to determine its digestion.

3rd. Of particular vessels destined to pump into the intestine the nutritious juices, produced by digestion, and to mix them with the blood.

In short we might consider as being in some sort auxillary to the digestive apparatus, certain organs with which certain animals seize their food and introduce it into the mouth; but these instruments principally serve other purposes and do not really belong to the apparatus of digestion.

15. The process of digestion is very complicated, and is made up of several phenomena or distinct acts, which take place in different parts of the digestive apparatus, and which have, for instruments, particular organs.

16. These phenomena are:

1st. The prehension of aliments.
2nd. Mastication.
3rd. Insalivation.
4th. Deglutition.
5th. Chymification, or stomach-digestion.
6th. Chylification, or intestinal digestion.
7th. Absorption of chyle.

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12. What are the terminations of the digestive tube?
13. What are the different portions of the alimentary canal?
14. What other organs belong to the digestive apparatus? What is the use of the teeth?
15. Is the process of digestion confined to the stomach exclusively?
16. What are the several acts or phenomena which constitute digestion?

8th. The expulsion of the residue, left by the aliments after digestion is finished.

We will now study successively these different phenomena, and the organs which produce them.

OF THE PREHENSION OF ALIMENTS.

17. The first phenomenon of the process of digestion is the prehension of aliments, that is, the act of seizing them and introducing them into the mouth.

18. The *mouth* is a cavity of an oval form, closed in front by the lips, on the sides by the cheeks and jaws, above by the palate, and below by the tongue; behind it is continuous with the pharynx or swallow, but is separated from it by a kind of curtain called the *velum palati*—(vail of the palate,) and which may be elevated or depressed so as to close the passage or leave it free. (*Plate* 3 *fig.* 1.)

19. The entrance to the mouth may be closed or opened by movements of the jaws and lips. On the prehension of aliment, the latter are separated to permit the entrance of the substance, and are immediately afterwards closed to prevent its escape.

20. With most animals the prehension of aliments is performed by the lips and jaws alone; but with some, other organs are employed to seize the substances and convey them to the mouth. With man and monkeys, the hand thus becomes the chief instrument of the prehension of aliments; with the elephant it is his trunk, and with parrots the claw.

21. With most animals the food remains for some time in the mouth, to be chewed and mixed with saliva.

OF MASTICATION.

22. Liquid aliments may be immediately swallowed; but solid food to be swallowed and digested with facility should be previously divided into very small morcels.

23. This division, called *mastication*, is effected by the aid of the teeth, which, set in motion by the jaws, press upon the food and cut or crush it.

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17. What is the prehension of ailments?
18. What is the mouth? What separates the mouth from the pharynx?
19. Is the entrance of the mouth provided with the means of being closed or opened?
20. How is the prehension of food effected?
21. Does the food pass at once from the mouth to the stomach?
22. May all kinds of aliment be immediately swallowed?
23. What is mastication? How is it effected?

24. In man and those animals which, in their organization, resemble us most, the two jaws are situated one above the other; the upper jaw is fixed immovably to the cranium; but the lower jaw is only attached to it, at its posterior part, and is there held on each side by a sort of hinge or joint, which permits it to be separated from and approached to the upper jaw.

25. The muscles which serve to bring the jaws together, and which, consequently, act most during mastication, are placed on each side of the head, in front of the ear, (*plate* 3, *fig.* 5.) and when we press the teeth together we can feel that they contract.

26. In most mammalia the edges of the jaws are armed with teeth.

27. *The teeth are small bodies of great hardness, which resemble bone very much, and which are planted in holes hollowed into the jaws, which holes are named alveoli.*

28. The fibrous pads which cover the edge of the jaws and which are called *gums*, serve, as well as the alveoli, to fix the teeth solidly in the position which they should occupy.

29. Generally each tooth is divided into two parts; one is situated without, and called the *crown*, the other, buried in the alveolus and terminated by one or more points, is called the root of the tooth. Finally, we often remark, between the crown and the root, a slight shrinking, called the *neck of the tooth.*

30. The teeth are composed of an internal substance called *ivory*, and a sort of extremely hard stony varnish which covers the surface, and is called *enamel.*

31. The crown of the tooth only is covered with enamel. The root has it not.

32. The teeth are formed in the interior of the jaws, and within little membraneous pouches called *dental capsules*, which are inclosed within the substance of the bone, and which present in their interior a fleshy *bud*, or granule, from the surface of which exudes the stony matter of which the tooth is composed. (*plate* 3, *fig.* 3 *and* 4.)

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24. What is the situation of the jaws? Are both jaws equally moveable?
25. Where are those muscles placed which move the jaws?
26. Have all animals got teeth?
27. What are the teeth? What are the alveoli?
28. What are the gums?
29. Into what parts is a tooth divided? What is the neck of a tooth?
30. What is the composition of teeth? What is ivory? What is enamel?
31. Have all parts of the tooth a covering of enamel
32. How are the teeth formed? What are the dental capsules? What do they contain? What office does this granule fulfil?

33. This stony matter is the ivory; it moulds itself upon the *bud* and takes its form; just in proportion as new quantities of ivory are deposited upon that already formed, the tooth enlarges, as well as the species of case, which it forms around the *bud*, which shrinks away until finally the little organ, being too much compressed, disappears; the tooth then ceases to grow.

34. In proportion as the tooth is formed, as we have just said, it rises in the alveolus, passes through the gum and shows itself without.

35. The enamel is formed at the superior portion of the dental capsule, and is applied upon the tooth, just to the extent it traverses that part of the capsule; it is for this reason that the root, which remains at the bottom of the alveolus, is never covered by it.

36. The teeth which are formed in the earliest period of life, are destined soon to fall, and to give place to other teeth, stronger and more solidly fixed. The first are called *milk teeth*, or *diciduous teeth*, or *teeth of the first dentition;* the second, the *permanent teeth*, or *teeth of second dentition.*

37. The teeth are divided into three kinds, (*plate* 3, *fig.* 3, *and plate* 4, *fig.* 1.) namely;

38. 1st. The *incisive* or *incisor*, which occupy the front of the mouth, and terminate in a thin cutting edge, have but one simple root and are fit for cutting the various aliments.

39. 2nd. The *canine*, which are placed on each side and next to the incisors, are in general long and pointed; they also have only a single root, but it buries deeply into the jaw; their principal use is to fix themselves in the flesh upon which the animal feeds, and to tear it.

40. 3d. The *molar* teeth or *grinders*, which are next to the canine, occupy the sides of the mouth; they are generally provided with several roots, and present a large, unequal crown, appropriate for grinding the food.

41. These molar teeth are subdivided into false molar (dentes bicuspidati) and great molar; the first are smaller than the second,

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33. How do teeth grow or increase in size? Do teeth always continue to grow? Does the bud or granule always exist in the tooth?

34. How does the tooth rise in the alveolus?

35. Where is the enamel formed? How is it applied? Why is there no enamel on the roots of the teeth?

36. Do the teeth of infancy remain through life?

37. How many kinds of teeth are there?

38. What are the incisor teeth? Where are they placed? What is their peculiar use?

39. Where are the canine teeth? What is their form? What is their use?

40. What is the situation and form of the molar teeth?

41. How are the molar teeth subdivided?

and are situated in front of them; the roots of the great molars are also more numerous, which gives them more solidity and power.

42. The number of teeth varies in different animals. Man, monkeys, the dog, the cat, etc., have the three sorts of teeth we have just described; but with the rabbit, the rat, and the other *gnawers*, (*rodentia*) the canine teeth are wanting: and in other quadrupeds, such as the sloth, there are no incisors; finally, there are also animals that are entirely unprovided with teeth, the ant-eater, and birds, for example.

43. The form of the teeth also varies in different animals, and we remark that these differences are in accordance with the nature or kind of aliment upon which these beings are destined to be nourished.

44. Thus with the dog, the cat, and other carnivorous animals, the molar teeth are sharp, and fitted to cut flesh, like scissors; (*plate* 4. *fig.* 2.) with the mole and hedge-hog, who live upon pretty hard insects, these teeth are armed with conical points which dovetail or fit reciprocally, and enable these animals to crush their prey with facility. With the frugivorous animals, monkeys, for example, the same teeth are large and their crown is armed with rounded elevations, suitable for crushing fruits; and with the ox and horse, which brouse or crop the grass, the crown of these teeth is still larger, and its surface is flat and striated like a mill stone.—(*Plate* 4. *fig.* 3.)

45. In man, the deciduous or milk teeth begin to appear about the sixth or seventh month, and fall about the seventh year. They are in number, twenty; namely, in each jaw:

Four Incisors,
Two Canine, one on each side,
And four molar, two on each side.

46. The permanent or teeth of second dentition are in number thirty-two.

47. The incisor and canine are the same in number as in the first dentition; but in place of two molars on each side of each jaw, there are five. The total number of molar teeth in adult man is consequently twenty, ten in each jaw.

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42. Are the same varieties and number of teeth found in all animals? What animals are without teeth?

43. Is the form of the teeth the same in all animals?

44. Does the form of the teeth of an animal bear any relation to its peculiar food?

45. At what age in man do the first teeth begin to appear? When do they fall? What is the number of the deciduous teeth? What is the number of each kind?

46. What is the number of the permanent teeth?

47. How do the permanent differ from the deciduous teeth? How many molar teeth is natural to an adult man?

48. The five molar teeth on each side are distinguished into two false molars and three great molars.

OF INSALIVATION.

49. During the act of mastication, the food is mixed with the saliva, which phenomenon is designated under the name of *insalivation.*

50. The *saliva* is a watery fluid, colorless and frothy, which is formed in particular organs, called *salivary glands.* (*Plate* 1. *fig,* 1, *and* 5.)

51. In man, these glands are six in number: three on each side of the face, and are called *parotid, sub-maxillary,* and *sub-lingual* glands.

52. The *parotid glands* are the largest; they are placed beneath the skin, between the ear and the jaw, and empty the saliva into the mouth by a long straight tube, which opens on the inside or internal face of the cheeks.

53. The *sub-maxillary* glands are smaller than the parotid, and are lodged below and behind the lower jaw.

54. The *sub-lingual* glands are smaller than the preceding and are found under the tongue.

55. The saliva serves to render the deglutition of food more easy, and contributes to accelerate digestion.

OF DEGLUTITION.

56. The food, conveniently prepared by mastication and insalivation, unites upon the back of the tongue in a little mass called an *alimentary ball, or bolus.*

57. The alimentary ball is next swallowed. We give the name of *deglutition* to this phenomenon which consists in the passing of food from the mouth into the stomach, through the pharynx and Œsophagus.

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48. How are the molar teeth distinguished?
49. What is insalivation?
50. What is saliva? where is it formed?
51. How many salivary glands exist in man?
52. Where are the parotid glands situated? Where do they open? Which of the salivary glands are largest?
53. What is the situation of the submaxillary glands?
54. What is the situation of the sublingual glands?
55. What is the use of the saliva?
56. What is the alimentary ball or bolus?
57. What is deglutition?

58. The opening which occupies the back part of the mouth, and which forms the communication between this cavity and the pharynx is called the *isthmus of the throat—isthmus faucium.* During mastication it is closed by the *veil of the palate,* (velum palati) but when deglutition is about to take place, this species of curtain is raised, and the alimentary ball is pushed into the pharynx.

59. The *pharynx, (plate* 3. *fig.* 1. *p. h.)* is a cavity situated between the base of the cranium, and the front of the neck; above, it communicates with the nasal fossæ by the posterior nares or nostrils, as well as with the mouth, and below it presents two openings: one by which it is continuous with the œsophagus, the other situated in front and called *glottis,* by which it communicates with the *larynx* and wind-pipe. We may compare it to a cross-road where the route followed by the air to get from the nose to the lungs, crosses the route followed by the food to get from the mouth to the œsophagus.

60. That deglutition may be effected, the alimentry ball must pass beneath the posterior nostrils and over the glottis without entering it, and descend directly into the œsophagus.

61. The veil of the palate, by elevating itself and being placed obliquely against the posterior wall of the pharynx, forms beneath the posterior nostrils, a sort of screen which hinders the food from mounting upwards and entering the nose from behind.

62. That the food may not enter the glottis, it closes at the moment of deglutition, and at the same time the larynx is raised up against the base of the tongue, a movement which forces a valve, situated above the glottis, and called *epiglottis,* (*plate* 3. *fig.* 1. *e. p.*) to fall and close the opening.

63. Sometimes, however, deglutition not being properly effected, we swallow crosswise, and the food penetrates into the larynx and at once brings on a fit of coughing.

64. The *œsophagus* is continuous with the pharynx: it is a long membraneous tube, which descends from the superior part of the neck, behind the wind pipe, enters the thorax, passes behind the heart and lungs, pierces the diaphragm and terminates in the stomach.

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58. What is the isthmus of the throat? Is this cavity open or closed during mastication?
59. What is the pharynx?
60. What is necessary to effectual deglutition?
61. What prevents the food from entering into the posterior nares?
62. What hinders food from entering the glottis?
63. What is the effect of food penetrating into the larynx?
64. What is the œsophagus?

65. The pharynx and œsophagus are furnished with a layer of fleshy fibres which are placed transversely in rings, and which, contracting successively from above downwards, convey the alimentary ball into the stomach.

LESSON VI.

Functions of Nutrition—*Stomach digestion, or chymification—Intestinal digestion, or chylification—Bile and liver—Pancreas, and Pancreatic juice—Large intestine—Absorption of chyle—Chyliferous vessels—Recapitulation of the functions of nutrition.*

OF STOMACH DIGESTION, OR, CHYMIFICATION.

1. Food begins to be digested in the stomach; it is there transformed into chyme, and we give to this phenomenon the name of stomach digestion, or chymification.

2. The *stomach, (plate 3. fig. 2. e. s.)* is a membraneous pouch, placed transversely at the superior part of the abdomen or belly. It has the form of a bag-pipe, and presents two openings; one situated to the left, and called *cardia,* communicates with the œsophagus; the other, called *pylorus,* occupies the right extremity of this organ and empties into the intestines.

3. Immediately after the passage of the alimentary ball, the cardia closes in such a manner as to hinder it from re-ascending again to the mouth. The pylorus is also closed, and the consequence is that the food is arrested in the stomach, and is forced to remain there a considerable time.

4. While the aliment thus sojourns in the stomach, it imbibes a peculiar liquid, called *gastric juice,* which converts it into *chyme.*

5. The *gastric juice* is a watery and acid liquid which is generated in a great number of very small cavities, lodged in the thickness of the parietes or coats of the stomach and named *gastric follicles;* each one of these follicles communicates with the interior of this organ by a small pore, and thus empties the gastric juice upon the food.

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65. How is the alimentary ball conveyed into the stomach?

1. Where does digestion commence? Into what is food changed in the stomach? What is the term applied to this change of food?

2. What is the stomach? What is the cardia? What is the pylorus?

3. What takes place after the alimentary ball passes into the stomach?

4. What is added to the alimentary mass while in the stomach?

5. What is gastric juice? Where is it formed?

6. By the action of the gastric juice, the food is softened and little by little changed into a thick, grayish pap, which is called *chyme.*

7. As soon as the chyme is formed, the pylorus relaxes and the stomach begins to perform a series of movements which, by degrees, push the alimentary mass towards this opening, and then into the intestine. These movements consist in the successive contraction of fleshy fibres which surround the stomach transversely, and which contract, one after the other from left to right.

OF INTESTINAL DIGESTION, OR CHYLIFICATION.

8. The chyme which issues from the stomach enters the intestine where it serves to form chyle.

9. The *intestine* (*plate* 3, *fig.* 2.) is a long membraneous tube, folded upon itself, which forms a continuation of the stomach and which, by its opposite extremity, opens outwardly. It is lodged in the abdomen, and is retained in its place by folds of a very fine membrane called *peritoneum*, which lines the parietes or walls of this cavity. These folds, which surround the stomach as well as the intestines, bear the name of *mesentery.*

10. The parietes of the intestine are furnished with fleshy fibres which surround them, and which, by contracting successively, push forward the matters contained within this tube. These movements are called ***vermiform*** or ***vermicular***, because they resemble those of a worm when crawling.

11. The length of the intestine is always very considerable, but varies very much in different animals. It is remarked that in those which are nourished by flesh exclusively, it is much shorter than in those which live on vegetable substances: thus in the lion, which is essentially carnivorous, it is only three times the length of the body; while in man, who is omnivorous, its length is about six or seven times that of the body, and in the sheep which eats grass only, it is just twenty-eight times this length.

12. The intestine is composed of two very distinct portions; the small intestine, and large intestine.

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6. What is chyme?
7. What takes place after the chyme is formed?
8. What is formed from the chyme?
9. What is the intestine? Where is it lodged? What retains it in its place?
10. What arrangement enables the intestine to push forward substances within it?
11. In what class of animals is the intestine longest? What is its length in man?

13. The *small intestine*, (*plate* 3. *fig*. 2. *i. g.*) is next to the stomach; it is narrower than the large intestine, and its external surface is smooth. Its length is very considerable, and it is subdivded into three portions, called: ***Duodenum***, ***Jejunum*** and ***Ilium***.

14. In the small intestine the chyle is formed, and digestion finished.

15. The phenomenon of chylification is produced by the mixture of the chyme with the bile and the pancreatic juice.

16. The *bile*, or *gall* is a greenish and very bitter liquid secreted by the liver.

17. The *liver*, (*plate* 3. *fig*. 2. *f*.) is a large reddish gland, and of a granular tissue. It is lodged in the superior part of the abdomen, to the right of the stomach, and presents upon its inferior surface, a membraneous pouch called the *gall bladder*. The bile accumulates in this *bladder*, as in a reservoir, and is afterwards poured into the duodenum by a narrow canal, called the *biliary duct*, or *ductus communis choledochus*.

18. The *pancreatic juice* is a watery liquid which very much resembles saliva, and which is formed in a gland situated behind the stomach, and called *pancreas*. It reaches the duodenum by a narrow canal, which arises in the pancreas, and empties near the opening of the biliary duct.

19. The chyme, mixed with the bile and pancreatic juice, passes through the whole length of the small intestine; and, during its passage separates into two parts: one called chyle, which is deposited upon the sides of the intestine to be absorbed; the other, composed of those parts of the food which are not nutritious, which continues its route and enters into the large intestine.

OF THE EXPULSION OF THE RESIDUE LEFT AFTER DIGESTION.

20. The alimentary matters which are not convertible into chyle. require to be rejected and conveyed out of the body, and for this purpose they enter into the large intestine and there accumulate,

13. What is the small intestine? What are its sub-divisions?

14. What takes place in the small intestine?

15. How is chylification produced?

16. What is bile?

17. What is the liver? Where is it situated? What part receives the bile from the gall bladder?

18. What is pancreatic juice? Where does this pancreatic juice go after leaving the pancreas?

19. What becomes of the chyme after being mixed with the bile and pancreatic juice?

20. What becomes of those matters which are not convertible into chyle?

21. The *large intestine* is the second portion of the intestinal tube; it differs from the small intestine in its calibre, its puffed form and in its uses. It is divided into three portions: the *cœcum*, the *colon*, and the *rectum*. (*Plate* 3. *fig*. 2. *c*. *r*.)

22. The *cœcum* is a swelling, or dilatation wherein the small intestine terminates: we remark there a thin worm-like prolongation, which terminates in a *cul de sac*, or blind canal, and is called the *cœcal appendix—appendicula vermiformis;* finally, we find on its inside a sort of valve which hinders the matters contained in its cavity from returning into the small intestine.

23. The *colon* is next to the *cœcum* and is continuous with the *rectum*, which terminates at the anal opening or fundament.

OF THE ABSORPTION OF CHYLE.

24. The chyle is a peculiar liquid, resulting from the digestion of food, and is deposited upon the parietes of the small intestines.

25. The appearance of this liquid varies somewhat according to the nature of the food from which it is formed; in general, it very much resembles milk.

26. The chyle is destined to be mixed with the blood, to repair the losses which this liquid sustains by nourishing the organs; and that this mixture may be effected, it is pumped up by a particular set of vessels which pour it into the veins.

27. This passage of the chyle from the intestine into the circulatory system is known under the name of *absorption of chyle.*

28. The absorption of chyle is performed by the lymphatic vessels of the intestines, which are called for this reason, *chyliferous vessels.*

29. These vessels, which are extremely delicate, arise from different parts of the small intestine by a multitude of branches, which, little by little, unite among themselves, as we remarked of the veins; and, after having traversed the small organs called *mesenteric glands*, empty into a conduit or canal called the *thoracic duct*. (*Plate* 3. *fig*. 6.)

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21. What is the large intestine? What are its divisions?
22. What is the cœcum? What is the cœcal appendix?
23. What is the colon?
24. What is chyle?
25. Is the appearance of chyle always the same?
26. What is the use of chyle? Into what blood vessels does the chyle enter?
27. What name is given to the passage of chyle into the circulation?
28. How is the absorption of chyle effected?
29. What are the chyliferous vessels? Where do they arise? Where do they empty?

30. This duct, or canal, which also receives the lymphatic vessels from other parts of the body, presents at its inferior extremity, a dilatation called the *reservoir of Pecquet*, or the *receptaculum chyli;* it lies closely glued to the anterior face of the vertebral column or spine, and mounts towards the thorax, to terminate near the base of the neck, in the subclavian vein of the left side.

31. The chyle, in passing through the mesenteric glands seems to be perfected in some degree; it assumes a rosy tint and becomes coagulable like the blood: but it still differs very much from this liquid, and we do not know, with certainty, in what part of the body it is changed into blood.

RECAPITULATION OF THE FUNCTIONS OF NUTRITION.

Such are the different functions by the aid of which the nutrition of the body is effected.

32. The alimentary substances, necessary for renewing the materials of which the organs are composed, are derived, as we have seen, from sources exterior to the animal, and, in order to serve the purposes of nutrition, require to undergo a peculiar preparation to which we give the name of *digestion.*

33. The chief of the functions of nutrition is, consequently, in man as in all other animals, that of DIGESTION.

34. The nutritious matters, thus elaborated, do not sojourn in the digestive cavity; in order to support the organs, they pass from this cavity into the very substance of the body itself, to be mixed with the blood. To this transportation from without to within, and the passage of all substances from without into the torrent of the circulation, is applied the term ABSORPTION.

35. The blood, to convey in this way, to all parts of the body, materials to repair the organs must necessarily be the seat of continual currents, and in fact, this liquid finds its way wherever there is life to be supported: this phenomenon is called the CIRCULATION.

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30. Where is the thoracic duct? Where does it terminate?

31. What change does chyle undergo while passing through the mesenetric glands? In what part of the body is chyle changed into blood?

32. To be available for nutrition what process does food necessarily undergo?

33. What is the chief function of nutrition?

34. What occurs next after digestion?

35. In order to fulfil its office of nourishing the organs, what is necessary to the blood?

36. In acting upon the tissues of the organs, the blood loses a part of its vivifying properties, and in order to regain them, requires to be brought into contact with the atmospheric air, which contact constitutes the phenomenon of RESPIRATION.

37. Finally, the materials separated from the substance of the organs, in consequence of the nutritive movement, are carried along by the blood, and are afterwards separated and rejected from the system in the form of liquids, or of vapours. These acts, which are in a measure, the completion of the nutritive process, bear the general names of EXHALATION and SECRETION.

38. To recapitulate; we see then that the functions of nutrition are constituted of several series of phenomena, each having its seat in different organs, and that these different acts are:

1st. Digestion;

2nd. Absorption;

3rd. Circulation;

4th. Simultaneous decomposition and recomposition of the organs of nutrition, properly so called;

5th. Respiration;

6th. Exhalation and Secretion.

LESSON VII.

FUNCTIONS OF RELATION—*Nervous system and sensibility.*

FUNCTIONS OF RELATION.

1. The phenomena of animal life or life of relation depend upon two faculties: that of sensation and that of motion.

2. These faculties, which do not exist in an equal degree of perfection in all animals, are wanting in vegetables. They are the result of an action of two apparatuses; the apparatus of sensations and the apparatus of motion.

3. The apparatus of sensations is composed of the nervous system and the organs of the senses.

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36. What is the object of respiration?
37. What completes the phenomenon of nutrition?
38. What are the several functions of nutrition?
1. Upon what do the phenomena of the functions of relation depend?
2. Do the faculties of sensation and motion exist in an equal degree in all animals? Do they exist in vegetables? Upon what do these faculties depend?
3. What parts compose the apparatus of sensations?

4. The apparatus of motion is composed of the muscles, of the bones, and of some other organs.

APPARATUS OF THE SENSATIONS.

5. Sensibility is the faculty of receiving impressions from surrounding objects.

6. This faculty has its seat in a particular apparatus called the Nervous System.

7. It is also through the medium of this nervous system that motion takes place, that the influence of the will makes itself felt in different parts of the body, and that the phenomena of intelligence is manifested.

8. We distinguish in this apparatus two principal parts, which are called the nervous system of animal life, and the nervous system of organic life.

9. The *nervous system of animal life* presides over the functions of the life of relation ; it is also called the *cerebro-spinal system*, because the brain and spinal marrow are the most important parts of it. (*plate* 5. *fig*, 1.)

10. The term *encephalon*, is applied to the great nervous mass formed by these two organs and the other central parts of the nervous system, lodged in the cavity of the cranium and in the canal which exists in the whole length of the vertebral column.

11. The *cranium* is a great cavity which occupies all the superior and posterior parts of the head, and which at the inferior part or base, presents several holes. One of these holes, which is very much larger than the other and placed a little behind, gives it a communication with the *vertebral canal.*

12. The vertebral canal is a cavity hollowed out in the vertebral column or spine, of which it occupies the whole length ; it consequently descends from the head, all along the back to the lowest extremity of the trunk and even into the tail, when the animal is provided with an appendix of this sort.

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4. What constitutes the apparatus of motion?
5. What is sensibility?
6. Upon what does sensibility depend?
7. Through what means is the influence of the will conveyed to different parts of the body?
8. What are the principal parts into which the apparatus of sensation is divided?
9. What is the office of the nervous system of animal life? Why is it called the cerebro-spinal system?
10. What is meant by the term encephalon?
11. What is the cranium?
12. What is the vertebral canal?

When we study the skeleton we shall recur to the description of these parts.

13. The *brain*, or cerebrum (*plate* 5. *fig.* 1.) is a voluminous viscus, of a very soft texture and of an oval form, which fills the greatest part of the interior of the cranium. It is divided on a middle line, by a very deep furrow, into two halves called *hemispheres of the brain*. Each of these hemispheres is subdivided, in its turn, into three lobes, and presents on its surface a great number of hollows and projections, folded on themselves, called the *convolutions of the brain*. We find in the interior, cavities called ventricles, and we distinguish in the substance of which it is composed, two sorts of matter, one white, called medullary, which occupies the interior of the mass of the brain, and the other, of a greyish color, forms its superficies and is called cortical.

14. Behind and below the cerebrum, or brain, we find, also in the cavity of the cranium, another nervous mass very much smaller, but of analagous structure, which is called the *cerebellum*. (*Plate* 5. *fig*, 1. *c. v.*)

15. The *spinal marrow* (*plate* 5. *fig.* 1. *m. e.*) arises from the inferior part of the brain and cerebellum. It has the form of a thick whitish cord, and descends from the interior of the cranium to the lowest part of the canal which pierces the vertebral column.

16. We give the name of *medulla oblongata* to the superior portion of the spinal marrow, which is enclosed in the cranium.

17. The *encephalon* is surrounded by different membranes, which serve to prevent it from wounding itself against the sides of the bony case which encloses it. One of these membranes, called the *arachnoid*, is extremely fine; another called the *dura mater*, is, on the contrary, very strong, and in the interior of the cranium forms plaits or folds which descend between the hemispheres of the cerebrum, and between this organ and the cerebellum, to sustain these parts and prevent them from pressing one upon the other.

18. A great number of soft whitish cords go from the brain and spinal marrow to all parts of the body; they are designated by the name of *nerves*. (*Plate* 5. *fig.* 1.)

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13. What is the brain? How is it divided? What are ventricles? What is the difference between the medullary and cortical parts of the brain?

14. What does the cranium contain besides the cerebrum?

15. What is the spinal marrow?

16. What is the medulla oblongata?

17. What are the coverings of the encephalon? What is the dura mater?

18. What name is given to those cords which go from the brain and spinal marrow to all parts of the body?

19. These nerves arise, some from the base of the brain, others from the sides of the spinal marrow. In man there are forty three pairs, of which, the first thirteen arise from the brain and medulla oblongata, and pass out of the cranium through holes in its base; and the remaining thirty pairs arise from the spinal marrow, and go out of the vertebral canal by holes situated on each side of the spine.

20. The nerves are divided into branches and ramuscules which are spread out in the different organs and in them become so extremely fine as to escape our vision. They possess extreme sensibility and the slightest wound of one of them causes acute pain.

21. The nerves give to different parts of the body to which they are distributed, the sensibility which these parts enjoy. They convey the impressions received by the organs to the brain, which is the seat of the perception of sensations.

It is also through the medium of the nerves that the influence of the WILL is communicated from the brain to different parts of the body, and that motion is performed.

22. Indeed, if we cut the nerves which go to a limb, it becomes immediately insensible and ceases to execute voluntary motion, or in other words it is *paralysed.*

23. Certain nerves serve only for the transmission of sensations, others serve only for motion, but the greater part fulfil both these functions at the same time; this arises from the union of a certain number of nervous fibres, of which some possess the first of these faculties, and others the second. At the point where the nerves issue from the spinal marrow, these two species of fibres are still separate and constitute two distinct roots, one situated before the other; *(Plate 5. fig. 2.)* the anterior root serves for motion, and the posterior for sensibity. When in a living animal we cut the anterior roots of all these nerves, he is incapable of moving, but preserves his sensibility; while, if we cut the posterior roots without wounding the anterior, the contrary is true.

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19. What is the origin of the nerves? How many pairs of nerves are found in man? What is the origin of the first thirteen pairs of nerves in man?

20. How are the nerves divided? To what parts are they distributed? Are they sensible?

21. What office is performed by the nerves?

22. What effect would be produced by cutting the nerves which go to a limb?

23. Do all nerves perform the same functions? How is it that some nerves serve for motion and also to transmit sensation? Which nervous roots serve for motion? Which nervous roots serve for sensation? If we cut the anterior roots of the nerves in a living animal what happens? What results from cutting the posterior roots?

24. That sensations may be perceived, it is necessary that the nerves transmit them from the point where they are produced to the brain, either directly, or through the intervention of the spinal marrow.

25. The brain is, at the same time, the seat of the WILL and of the perception of sensations; when, in consequence of a wound or strong compression, this organ cannot perform its functions, the animal becomes insensible, ceases to execute voluntary motions and falls into a state resembling profound sleep.

26. It is remarkable that the nerves which arise from the right side of the spinal marrow communicate with the left hemisphere of the cerebrum and *vice versa;* this results from the crossing of the fibres in the *medulla oblongata*, and hence it is that when the brain is paralysed on one side only, it is the members of the opposite side of the body which lose their sensibility and motion.

27. Farther, the brain, although the seat of perception of sensations, is itself very slightly sensible; we may prick or cut it in a living animal without causing pain.

28. The spinal marrow is, on the contrary, extremely sensible, and when it is wounded, the animal is convulsed; if it be cut or compressed so that it cannot perform its functions, all the parts of the body whose nerves arise below the point of injury are at once paralysed.

29. The cerebellum seems to be designed to regulate motion.

30. The second portion of the nervous system, or NERVOUS SYSTEM OF ORGANIC LIFE, communicates with the nerves which arise from the spinal marrow by a great number of small filiments, but it is distinct from it.

31. This apparatus, which is also designated under the name of *ganglionic system*, or *great sympathetic*, on account of the connection which it establishes between different parts of the body, is composed of a great number of small nervous masses called

24. What is necessary to enable an animal to perceive impressions made upon it?

25. What occurs, if, from any cause, the functions of the brain be interrupted?

26. What is remarkable in the origin of the nerves?

27. Is the brain itself sensible?

28. Is the spinal marrow sensible or not? When the spinal marrow is compressed or wounded, what occurs?

29. What seems to be the office of the cerebellum?

30. Does the nervous system of organic life communicate with the nervous system of relation?

31. Why is the nervous system of organic life called the great sympathetic? Why is it also called the ganglionic system? What is a ganglion? To what parts are those nerves ditsributed which arise from the ganglions?

ganglions, situated in the neck, in the thorax, and in the abdomen in front of the vertebral column, and tied to each other by communicating cords; a multitude of nerves arise from these ganglions and are spread out in the heart, the lungs, the intestines, the glands and other organs of vegetative life.

32. These parts of the body which receive their nerves from the ganglionic system are slightly sensible, and the movements which they execute are independent of the WILL.

33. The principal nerves of sensibility terminate in particular organs, through the medium of which they receive and transmit to the brain, the sensations produced upon us by surrounding objects. These organs are each destined to receive sensations of a certain kind, and are called organs of the senses.

LESSON VIII.

FUNCTIONS OF RELATION—*Sense of touch—Skin—Hands—Hair—Beard—Nails—Horns—Mode of formation—Sense of smell—Olfactory apparatus—Sense of taste—Sense of hearing—Auditory apparatus.*

1. We give the name of *Senses* to those faculties by the aid of which animals take cognizance of the properties of bodies which surround them.

2. Bodies may differ from each other in different ways; in their weight, their hardness, their volume, their temperature, &c. by their odour, their taste, their form, and their color, or by the sounds which they afford.

3. These various qualities cannot be appreciated by the same organ; the organ which perceives taste for example, is not sensible of the color, or odour of bodies; therefore, the faculty of experiencing sensations from the influence derived from each one of these different kinds of the properties of external objects, is the attribute of a particular organ.

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32. Do the movements of those parts of the body supplied with nerves from the ganglionic system, depend upon the influence of the WILL? Are the parts thus supplied very sensible?

33. How do the principal nerves of sensibility terminate?

1. What are the senses?

2. How do bodies differ from each other?

3. Is any one organ capable of appreciating all the properties of bodies?

4. These faculties or senses, in man and most animals are five in number; namely: *touch*, *taste*, *smell*, *hearing*, and *sight*.

5. Touch and taste are only exercised upon bodies which are brought into contact with those organs which are the seat of those senses. Smell, hearing, and sight, make us acquainted with certain properties of objects at a greater or less distance from us.

6. All animals do not possess the senses in an equal number with man; in some, there is neither organ of sight, nor organ of hearing, nor organ of smell; such is the oyster for example: in others, one or another of these instruments is wanting.

We will now consider each one of the senses, and the organs which are the seat of them.

OF THE SENSE OF TOUCH.

7. Touch is the sense which reveals to us the contact of foreign bodies with our organs and informs us of the nature of their surfaces whether rough or smooth, their movements, the degree of their consistence, their temperature, and, to a certain extent, their form, volume and weight.

8. *Tact* is a passive touch, but this function sometimes becomes active: it is more especially called *touch*, when the sensibility is most exquisite and the surface, which is its seat, can in a manner mould itself to objects.

9. Tactile sensibility is spread out in all parts of the surface of the body, and resides in the *skin*.

10. The skin is the membrane which covers or clothes the body. It is principally composed of two parts, one called the *corion* or *derma*, or true skin, the other, the *epidermis* or cuticle, or scarf-skin.

11. The *epidermis* is the most superficial layer of the skin; it is a sort of thick varnish which covers the derma and serves to protect it against the contact of hard bodies, and prevent it from becoming dry by the action of the air.

12. The derma is the thickest and most important part of the skin; it is beneath the epidermis, and adheres to the subjacent

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4. What is the number of the senses? What are they called?

5. What is necessary for the exercise of the faculties of touch and taste? What faculties convey to us notions of bodies without contact?

6. Have all animals the same number of senses as man?

7. What is touch?

8. What is tact? When does it become touch?

9. What is the seat of tactile sensibility?

10. What is the skin? Of what parts is it composed?

11. What is the epidermis? What is the use of the epidermis or cuticle?

12. What is the derma? Where is it placed? Has the derma any nerves? What form the papillæ of the derma? Where is the derma most sensible?

parts by its internal face. A considerable number of nerves are distributed in it, and form upon its surface small elevations called *papillæ.* To these nerves the skin owes its sensibility, which is greatest in those parts where there is the greatrst number of papillæ, as in the ends of the fingers for example.

13. The epidermis is applied upon these nervous papillæ: it is not itself endowed with sensibility, and renders the sense of touch less delicate in proportion to its thickness. Frequent contact with rough and hard substances tends to increase its thickness; thus, the hands of those persons who perform laborious work have the epidermis thicker and less sensible than those whose occupation does not place them in the same circumstances.

14. Hair, beard, nails, horns, &c., are productions formed by small secreting organs, lodged in the substance of the skin; they are developed, like the teeth, by the addition of new portions of their substance upon that already formed, and are not like living organs, the seat of a nutritive movement. We give the name of *bulb*, to the secreting organs of the hair and beard.

15. Finally, there exists in the thickness of the derma, little follicles which secrete the sweat, a liquid which is more or less acid.

16. The contact of an object with any point of the surface of the skin is sufficient to determine a sensation there; but, that touch may be exercised, it is necessary that the part where this contact takes place shall be so formed as to apply itself exactly, and, in a manner, mould itself to the object which the animal wishes to feel; this kind of perfected *tact* has its seat in particular organs called, *organs of touch.*

17. In man, the hand is the special organ of touch, and its structure is admirably well adapted to the exercise of this sense. The fineness of the skin, its great sensibility, the species of cushion formed by the subcutaneous fat at the extremities of the fingers, the length and flexibility of these organs and the capability of opposing the thumb to the other fingers, like a pair of plyers or forceps, are so many conditions essentially favourable to the delicacy of this sense, and enables us to appreciate with great exactitude the qualities of those bodies we may feel.

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13. Is the epidermis itself sensible? What effect has the thickening of the cuticle upon the sensibility of a part?

14. How are hair, beard, horns, nails, &c. produced? What name is given to the secreting organs of the hair and beard?

15. What is the origin of sweat or perspiration?

16. Does contact of an object with any part of the skin determine sensation at that part? Is this contact sufficient for the exercise of the faculty of touch?

17. What is the organ of touch in man? What are the circumstances which render the hand so admirably adapted to its purpose?

18. Most animals have very imperfect instruments of touch, and, in general, the greater part of the surface of their bodies is slightly or not at all sensible, on account of the hairs, feathers, scales, and other hard parts, with which their skins are covered.

OF THE SENSE OF TASTE.

19. Taste is a sense which makes us acquainted with the savor or taste of substances.

20. Like touch, taste is exercised by contact only. Its seat is in the mouth.

21. The parts of the mouth where this peculiar kind of sensibility resides are, the edges of the tongue and the arch of the palate.

22. All substances are not sapid; those which are not soluble in water seldom are.

23. In order to act upon the sense of taste, it is necessary that the sapid substances which the animal introduces into its mouth, should be dissolved by the fluids poured into this cavity by the salivary glands, or by some other liquid. It is in a state of solution, that savors are perceived by the nerves of taste, which are spread out upon the surface of the tongue, and which transmit to the brain the impressions of this sense.

OF THE SENSE OF SMELL.

24. The sense of smell reveals to us the existence of odours and enables us to appreciate them.

25. Odours are produced by extremely fine particles, which escape from odorous substances, and which are diffused in the air like a vapour.

26. That odours may act upon the sense of smell, the odoriferous particles must come in contact with the surface of the organ wherein this sense is seated.

27. The sense of smell is exercised in a peculiar apparatus, called the nasal fossæ.

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18. Are most animals well supplied with organs of touch?

19. What is taste?

20. Where is the sense of taste situated? Can this sense be exercised without contact?

21. What parts of the mouth are endowed with the sense of taste?

22. Are all substances sapid?

23. What conditions are necessary to operate on the sense of taste?

24. What is the sense of smell?

25. How are odours produced?

26. What is a necessary condition in order to act upon the sense of smell?

27. Where is the sense of smell situated?

28. The *nasal fossæ*, (*plate* 5. *fig.* 6.) are two large cavities in the face, which communicate externally by the openings of the nose or nostrils, and which open behind into the pharynx by the posterior nares or nostrils. The walls of these cavities form in front a more or less prominent ridge, which constitutes the nose, and a verticle partition separates one from the other. Finally, they are lined by a soft and very delicate membrane, called the *pituitary membrane.*

29. The first pair of cerebral nerves, which are called the *olfactory nerves*, are distributed to this membrane, and transmit to the brain the impressions produced by the contact of odoriferous particles.

30. The air which traverses the nasal fossæ in order to reach the lungs, carries with it the odorous particles of substances, and it is by touching the pituitary membrane that these particles produce the sensation of smells. The form of the nasal fossæ is such, that the air is carried towards their superior parts, where the greatest number of the dilicate filaments of the *olfactory* nerve is distributed.

31. It is vulgarly believed that the humors with which the pituitary membrane is lubricated come from the brain; but this is an error. They are secreted by this membrane itself, and the slight diseases known under the name of cold in the head, *rheum of the head* are nothing else then an inflamation of this membrane.

OF THE SENSE OF HEARING.

32. Hearing is the sense which enables us to perceive sounds.

33. Sounds are produced by very rapid oscillatory movements which are manifested in sonorous bodies, and which are called *vibrations.*

34. Sonorous vibrations are communicated from the bodies in which they are produced to the surrounding air, and are thus propagated, little by little, or nearer and nearer, like the undulation produced on the surface of smooth water by casting a stone into it.

35. That sounds may act upon our senses, the oscillatory motion must reach the bottom of the apparatus of hearing, that it

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28. What are the nasal fossæ or nostrils? What is the name of the lining membrane of the nose?

29. What nerves are distributed to the pituitary membrane?

30. How is the sense of smells perceived?

31. What is the origin of the humors which cover the pituitary membrane? What diseases consist of inflamation of this membrane?

32. What is the sense of hearing?

33. How are sounds produced? What are vibrations?

34. How are sonorous vibrations propagated?

35. What condition is necessary to produce sensation from sounds?

may agitate the extremity of the nerve destined to transmit the sensation which it produces.

36. The apparatus of hearing is called the ear; it is double and is symetrically placed on each side of the head. Each of these apparatuses is lodged in the interior of one of the bones of the cranium, called the *temporal* bone. That part of the temporal bone which contains it, is extremely hard and for this reason has received the name of *petrous*.

37. The apparatus of hearing is very complicated in its structure; it may be divided into three principal parts, which anatomists have called the *external ear*, *the middle ear or cavity of the tympanum*, and the *internal ear or labyrinth*. (*Plate* 4. *fig*. 4.)

38. The *external ear* is composed of the *pavilion of the ear*—(*external ear*) and the *auditory canal*, (meatus auditorius externus.)

39. The external ear or *pavilion* of the ear (*plate* 4. *fig*. 4. *p*.) is a very elastic cartilagenous plate which surrounds the entrance to the auditory apparatus, and presents, in many animals, the form of a trumpet which serves to direct sounds towards the interior of the ear. In man the pavilion of the ear presents many ridges and furrows or anfractuosities arising from the folds of the cartilagenous plate which forms it.

40. The *auricular canal* or *external auditory canal*—meatus auditorius externus, (*plate* 4. *fig*. 4. *c. a*.) is a species of tube which commences at the bottom of a widened part of the pavilion called *concha*, and buries itself in the temporal bone; it is gaping at its external extremity; but ends internally, in a species of membraneous partition, named *membrana tympani*—drum of the ear—which separates it from the middle ear.

41. The *middle ear* is composed of the cavity of the tympanum and some small accessory parts.

42. The name of *tympanum*, (*plate* 4. *fig*. 4. *c. a. i*.) is given to a small cavity of irregular form which is hollowed out in the petrous portion of the temporal bone, and which is found to lie

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36. What is the name of the apparatus of hearing? Is it double or single? Where is it situated? What is that part of the temporal bone called which contains the apparatus of hearing?

37. How is the ear divided?

38. What are the divisions of the external ear?

39. Describe the external ear?

40. What is the situation of the external auditory canal? What is the membrana tympani?

41. Of what does the middle ear consist?

42. What is the tympanum? Where is it situated? Through what passage does air enter the tympanum?

between the auditory canal and the internal ear. It is filled with air, which gets there through a canal called the *Eustachian tube*, which opens into the superior part of the pharynx.

43. The entrance to the tympanum is closed by a very thin partition, which is stretched like the parchment over a drum, and hence the name, *tympanum*. This membrane serves to facilitate the transmission of sounds from without to the very bottom of the auditory apparatus, and also to moderate the intensity of sounds; for it is so arranged. that it can be stretched or relaxed; and when stretched, it transmits sound less perfectly.

44. We also remark in the interior of the tympanum, a transverse chain, formed of four small bones, named on account of their shape, the *malleus*, (hammer) *incus*, (anvil) *lenticular bone*, or *os orbiculare*, and *stapes* (stirrup) (*plate* 4. *fig*. 5. *and* 6.)

25. The malleus rests upon the membrane of the tympanum, and affords attachment to muscles, which, by contracting, may cause it to press more or less strongly upon the membrane; in this way it is stretched or relaxed to adapt itself to the intensity of the sounds by which it is struck.

46. In the interior of the cavity of the tympanum there are two small openings, which are closed up by membranes stretched over them like that of the tympanum; they lead to the internal ear. One of them called the *fenestra ovalis*, or *foramen ovale*, is in contact with the base of the *stapes*; the other, called the *fenestra rotunda*, or *foramen rotundum*, is situated a little lower down. The cavity of the tympanum also communicates with a great number of cells which are in the substance of the *petrous* bone.

47. The *internal ear* is composed of three parts, namely, the vestibule, the semi-circular canals and the cochlea. (*plate* 4. *fig*. 4.) These organs are filled with a watery liquid in which the filaments of the acoustic nerve terminate.

48. The vestibule and the acoustic nerves constitute the essential part of the auditory apparatus; the other parts which we have just enumerated are destined to perfect this apparatus, and for the most part, may be destroyed, even in man, without

43. Of what use is the membrana tympani? Does it modify sounds?

44. What is found in the interior of the tympanum?

45. What bone gives attachment to the small muscles which act on the membrane of the tympanum?

46. In the cavity of the tympanum are found two small openings; to what part do they lead? Which foramen has the stapes bone attached to it? With what other parts does the cavity of the tympanum communicate?

47. Of what parts is the internal ear composed? With what is these organs filled, and what terminates in them?

48. What essentially constitutes the auditory apparatus?

deafness being the necessary consequence of their loss; they are absent in a great many animals.

49. For example, birds have not the pavilion of the ear; reptiles are destitute of the pavilion and the auditory canal; in fish all parts of the middle ear or tympanum are wanting, and in other animals, such as the craw-fish, the apparatus of hearing consists only of a small vesicle similar to the vestibule.

LESSON IX.

FUNCTIONS OF RELATION—*Sense of sight—Light—Apparatus of vision—Eye-brows—Eye lids—Lachyrmal apparatus—Muscles of the eye—Structure of the eye—Use of different parts of the eye—Voice.*

OF THE SIGHT.

1. Sight is the sense by which we perceive the form, color, volume, and position of objects that surround us.

2. This sense, which Buffon called "distant touch," is exercised at a distance, through the medium of light.

3. To comprehend the mechanism of sight, it is not sufficient to know the structure of the eye; we must also be familiar with some of the properties of light, the study of which subject belongs to that branch of science called Optics.

4. Light is a fluid which fills space and illuminates the earth. It eminates from luminous bodies, such as the sun, the fixed stars, and substances in combustion, and diffuses itself afar with inconceivable rapidity.

5. In proportion as the rays become distant from the body from which they eminate, they diverge one from the other, and for this reason bodies are better lighted, the nearer they are to the illuminating body.

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49. Is the organ of hearing the same in all its parts in all animals?

1. What is sight?

2. By what means is the sense of sight exercised?

3. Is a knowledge of the structure of the eye, sufficient in itself to teach us the mechanism of sight?

4. What is light? What are the sources of light?

5. Why are bodies better lighted when near the illuminating body?

6. When light meets with a body, it either passes through it, or is reflected from it, or it may be absorbed.

7. Those bodies which permit light to pass through them are called *transparent;* those which oppose its passage are called *opaque.*

8. In order to see an object, the rays of light which eminate from it, or which are reflected by it, must reach to the bottom of the eye. For this reason, an opaque body placed between the eye and the object at which we look, renders the latter invisible.

9. The surfaces of opaque bodies do not always reflect back the light the same as they receive it. As we have said, there are some which absorb all the rays; such bodies are called black. Bodies that reflect all the rays, or nearly all, are white, but those which decompose them are coloured.

10. Color is not inherent in bodies; it depends upon the manner in which they decompose the light, and the kind of luminous ray that the coloured body can reflect. Each ordinary ray of light, though it appears colorless to us, is composed of seven differently colored rays: there is a very simple mode of being convinced of this fact; if we receive a bundle of luminous rays, which have passed through a glass prism, upon a sheet of paper, instead of producing a white image, it will form an oblong image, in which may distinguish the following seven colors, namely: Red, Orange, Yellow, Green, Blue, Indigo, Violet. Now, objects appear to us white, when they reflect the light without decomposing it, and colored in this or that manner, when they decompose it like the prism, and absorb some rays and reflect others.

11. In passing through transparent bodies, rays of light sometimes continue to follow their primitive direction. But on other occasions this direction changes, making them approach to, or diverge from each other. For this reason, when a straight stick is plunged half of its length into water, it seems as if it were broken; and it is by acting this way upon light, that the concave or convex glasses of spectacles, enlarge or diminish the images of bodies. This deviation of light is called *refraction.*

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6. When light meets with a body, what takes place?

7. When are bodies transparent? When are bodies opaque?

8. What is necessary to enable us to perceive an object?

9. Do all bodies reflect light? What is the color of those bodies which absorb all the rays? What is the color of those bodies which reflect all the rays? What is the color of those bodies which reflect the rays?

10. Upon what does the color of bodies depend? Of how many colors is a ray of light composed? What are these colors? When do bodies appear to be white? When are bodies coloured?

11. What is refraction?

12. In order to see a body, the rays of light which part from it must reach the bottom of the eye, and there paint an image of the object; the impression thus produced, is received by a particular nerve, and by it transmitted to the brain which receives the sensation.

13. The apparatus of sight is composed: 1st. of the organ of vision, which consists of the globe of the eye and its nerve; 2nd. of the accessary organs of vision, that is, of the protectors and movers of the eye.

14. The *globe of the eye* is a hollow ball, filled with certain humors, and so arranged that the rays of light may penetrate it, and collect upon the nerve which occupies its bottom.

15. The sides of this globe are composed of a very solid membrane which consists of two parts: one, situated in front and named, *transparent cornea;* the other, occupying the sides and bottom, and called *sclerotica. (plate 5. fig. 3. and 4.)*

16. The *sclerotica* surrounds the eye in all parts, except in front; it is white, and entirely opaque: it is this part which is vulgarly called *the white of the eye.*

17. The *transparent cornea* is, on the contrary, diaphanous; it is framed into a great hole in the sclerotica, and resembles a somewhat arched watch-glass, set into a hollow white ball.

18. A short distance behind the transparent cornea, is found a sort of vertical partition, named *iris* from its varied colors which are seen through the cornea. Its centre is pierced by an opening which is susceptible of enlargement and diminution; it is called the *pupil.*

19. The space comprised between the cornea and the iris is called the *anterior chamber of the eye,* which is filled with a transparent liquid called the *aqueous humor.*

20. Behind the pupil we find the *chrystalline lens*, which is a transparent lens of a globular form, and behind the *chrystalline* we find a diaphanous mass soft as jelly, which is called *vitreous humor* and which fills all the interior of the globe of the eye.

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12. In what manner is the image of an object conveyed to the brain?
13. Of what parts is the apparatus of sight composed?
14. What is the globe of the eye?
15. Of what parts do the sides of the globe of the eye consist?
16. What is the sclerotica?
17. What is the transparent cornea?
18. What is the iris? Why is it so called? What is the pupil?
19. What is that space called which is comprised between the cornea and iris? What does the anterior chamber of the eye contain?
20. What do we find behind the pupil? What is the form of the chrystalline lens? What fills the interior of the globe of the eye?

21. The *optic nerve*, which comes from the brain, enters the globe of the eye through the posterior part of the sclerotica, and then expands itself out into a soft whitish membrane, called *retina*, which envelops the hinder part of the vitreous humor. Between the retina and the internal face of the sclerotica, we find another membrane, generally colored black, called the *choroid*, (*tunica choroides*) It is this coat which is seen through the retina and the humors of the eye when we look towards the bottom of the organ, and which gives to the pupil the appearance of being a black spot instead of a hole.

Such are the different parts which compose the globe of the eye. Let us pass to the consideration of vision.

22. The rays of light which leave an object at which we look, penetrate to the retina and there form a small but very clear image of that object.

23. The manner in which the light acts in the interior of the eye, is the same as in the optical instrument called a *camera obscura*. The different transparent parts through which the luminous rays pass to get from the cornea to the retina, have the effect of collecting the rays and concentrating them upon the retina. It is the chrystalline lens especially that determines this concentration of light, and upon this phenomenon depends the formation of images at the bottom of the eye.

24. When the eye concentrates the light with too much force, we cannot see distinctly, except at a very short distance ; to this infirmity is applied the term *myopia*, or *short sightedness ;* when, on the contrary, the luminous rays are not sufficiently concentrated in their passage through the eye, only distant objects are distinctly seen, and this defect is called *presbyopia* or long-sightedness ; this feebleness in the refracting power of the eye, is a consequence of old age, and is remedied by wearing convex glasses before the eyes. To give short-sighted people a longer vision, we must, on the contrary, employ spectacles with concave glasses which scatter the luminous rays, and thus counterbalance the too strong refracting force of the eye.

21. Where does the optic nerve enter the eye? What is the retina ? What is found between the retina and internal face of the sclerotica ? Why does the pupil seem to be a black spot instead of a hole ?

22. On what part of the eye are the images of objects formed ?

23. In what manner does light act in the interior of the eye ? What effect have the different parts of the interior of the eye upon the light passing from the cornea to the retina? What part especially determines the concentration of light in the eye ?

24. What is the consequence of a too great concentration of light by the interior parts of the eye ? What is the cause of long sightedness ? What kind of spectacles are required for short-sighted people?

25. The iris is contractile, and its principal use is to regulate the quantity of light which should penetrate to the bottom of the eye; when the light is too vivid, it contracts, and consequently diminishes the pupil, through which the rays must pass to reach the retina; in the dark on the contrary the pupil is enlarged.

26. The choroid membrane, which lines the internal face of the globe of the eye, is covered with a sort of black varnish, which absorbs all the luminous rays, not necessary for vision.

27. Images painted, if we may use this term, upon the retina, are transmitted to the brain through the medium of the optic nerve.

28. The accessary parts of the apparatus of vision are of two kinds; the one is designed to protect the globe or ball of the eye, the other to move it and give the required direction to fulfil its functions in the best manner.

29. The protecting organs of the eye are: 1st, the orbit, 2nd, the eye-lids, 3rd, the lachrymal apparatus, 4th, the eye-brows.

30. The *orbit* is a great bony cavity, hollowed out in the face on each side of the nose. It has the form of a cone, the base of which is open and directed forward; its parietes are formed, above by the frontal bone; below, by the superior maxillary bone; externally, or outwardly, by the malar or cheek bone, and internally by the bones which belong partly to the nose. The bottom of the orbit is pierced by a large hole, which communicates with the cranium, and gives passage to the optic nerve.

31. The ball of the eye is set into this cavity and rests upon a sort of cushion formed of fat. It is protected in the same way on all sides except in front, and there we find the eye-lids.

32. The eye-lids are moveable curtains, stretched in front of the ball of the eye. On the outside they are formed of the skin; internally they are lined by a smooth membrane which is reflected over the front of the eye upon the sclerotica, and this membrane is called the *membrana conjunctiva;* between these two membranes—the conjunctiva, and the skin—there is placed a thin plate of fibrous and resisting substance, called *tarsus* or palpebral cartilage, as well as muscles which serve to move these organs. In

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25. What is the action of the iris?
26. What is the use of the black covering of the choroid coat?
27. How are images upon the retina transmitted to the brain?
28. What are the uses of the accessary parts of the apparatus of vision?
29. What are the protecting organs of the eye?
30. What is the orbit?
31. Upon what does the ball of the eye rest?
32. What are the eye lids? Of what do they consist? What is their number?

man there are two eye-lids, one superior, and the other inferior. The superior eye-lid is larger than the inferior.

33. Each eye-lid has two edges or borders; one is continuous with the skin, the other is free. The free border of the eye-lids, is bristled with delicate hairs, called *cilia*, or eye-lashes. The use of the cilia is to form a kind of little grating in front of the eye, to arrest foreign bodies, the presence of which would interfere with the exercise of vision.

34. The eye-lids perform the double office of protecting the ball of the eye by closing in front of it, and of rendering it inaccessible to luminous rays, the brilliancy of which might disturb sleep. Besides, the eye-lids by their alternate movement of depression and elevation, spread over the front of the globe of the eye the tears, an aqueous liquid, which prevents the cornea from drying, and also favors the motion of the eye-lids.

35. The *lachrymal apparatus* which secretes the tears is composed of several organs, some of which are destined to form this liquid and pour it over the front of the eye; while others convey from the eye, the tears whose presence would become troublesome if too much prolonged. The first organs are:

36. 1st. The *lachrymal gland*, a small body the size of an almond placed at the exterior and superior part of the globe of the eye, between it and the orbitary cavity: (*plate* 5. *fig.* 5. *g. l.*) it serves to secrete the tears; 2nd. Several small canals which arise in this gland and open upon the internal face of the adhering border of the upper eye-lid, where they constantly pour upon the conjunctiva the lachrymal fluid, or tears.

37. The organs destined to carry away the tears which have been spread over the front of the eye, and to convey them into the nasal fossæ, are two little canals which open upon the free border of the eye-lids, near the internal angle of the eye, by two small orifices called the *lachrymal points*—puncta lachrymalia. (*Plate* 5. *fig.* 5. *p. l.*) Each of these points (placed one above and the other below) communicate with a little curved canal, which runs inwards and opens into a vertical conduit, larger in size, called the *nasal canal*, which empties into the nasal fossæ. The function of these lachrymal *puncta* is to pump the tears as fast as they are

33. What is the use of the eye lashes?

34. What is the use of the eye lids?

35. What is the use of the lachrymal apparatus?

36. Of what use is the lachrymal gland? How do the tears pass from this gland?

37. What are the puncta lachrymalia? What becomes of the tears after they have moistened the ball of the eye? What is the nasal canal? Explain the phenomenon of crying?

poured over the eye: in this way the fluid is carried off as fast as it is formed. Under particular circumstances, the equilibrium between these two phenomena is destroyed; and, either that the tears are secreted in too large a quantity, or the lachrymal puncta do not pump them off with proportioned activity, or they are interrupted in their passage through the lachrymal ducts and nasal canal, this fluid overruns the eye-lids and falls in considerable quantity along the cheeks.

38. The *eye-brows*, which form a ridge above the orbit and are garnished with hairs, also belong to the protecting organs of the eye, but their use is less important than that of those organs of which we have just spoken. They assist in shading the eyes when exposed to strong light.

39. The *motor organs of the eye* are six muscles, fixed by their anterior extremities into the sclerotica, and by their posterior extremities to the bottom of the orbit. (*Plate* 5. *fig;* 4. *m.*) By contracting, they direct the occular globe, to the side where their muscular fibres are placed.

40. The apparatus of vision presents nearly the same structure in the mammalia, birds, reptiles, and fish, but in insects the organization of the eyes is very different, as we shall see when we come to the history of these animals.

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41. Through the medium of the senses we take cognizance of all that surrounds us; but our relations with the external world would be very imperfect if we could not act upon these bodies, change place and express what we feel. Indeed we do possess this power, which is the result of the faculty of producing sounds, and of the faculty of executing motion.

OF THE VOICE.

42. Voice consists in the production of a particular sound, by the aid of the air which escapes from the lungs. A great number of organs take part in the performance of this function; but that one which is especially its seat is the *larynx*, a sort of cartilaginous tube which, at its superior extremity, opens into the pharynx by an opening named *glottis*, and which, by its inferior opening communicates with the windpipe, which is, in a manner, only a prolongation of it. (*Plate* 5. *fig.* 7. *and* 8.)

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38. What are the eye brows?

39. What are the motor organs of the eye?

40. Is the organ of vision the same in all animals?

41. What powers are requisite, besides the senses to complete our relations with the external world?

42. What is voice? Is voice produced by the function of a single organ?

43. The larynx is essentially the organ which produces the voice, and it is the passage of air through its interior which occasions the sounds there formed. To deprive an animal of this faculty, it is only necessary to open the wind-pipe, for then the air finding an exit through the accidental opening, no longer passes through the larynx, nor is it subjected to the vibrations which would have been imparted by this organ.

44. In the interior of the larynx, there are two membraneous folds which have a direction forward and backward, pretty closely resembling the edges of a buttonhole; they are called the *inferior ligaments of the glottis*, or *vocal cords*, and the production of sound depends principally upon their action upon the air, which passes through the species of slit formed by them.

45. Words are produced by the modifications which the column of air receives in the interior of the mouth, by the combined action of the palate, the cheeks, the tongue, and lips.

LESSON X.

FUNCTIONS OF RELATION—*Apparatus of motion—The Skeleton—Structure of bones—their composition—Enumeration of the bones—Articulations—Muscles—Attitudes—Locomotion.*

MOTION.

1. The organs of motion are divided into two classes: 1st. those which act and produce the *motive* force. 2nd. Those to which the action is communicated; or, in other words, they are divided into the active and passive organs of locomotion.

2. The first are the muscles; the second are the bones or those parts which hold their place.

OF THE OSSEOUS SYSTEM.

3. Man and all the other mammalia, as well as birds, reptiles, and fish, have in their structure solid parts which are called *bones*, and the union of these bones, one with the other, constitutes the *skeleton*. (*Plate* 6. *fig*. 1.)

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43. What is the larynx? How may it be proved that the larynx is essentially the organ of voice?

44. What is meant by the vocal cords?

45. How are words produced?

1. How are the organs of motion divided?

2. Which are the active organs of motion? Which are the passive organs of motion?

3. What are bones? What do they constitute?

4. The skeleton is a kind of frame which gives firmness to the body, in a considerable degree, determines its dimensions and its form, serves to protect the organs which are most important to life, and furnishes the passive instruments of motion, to the function of locomotion.

OF THE COMPOSITION OF BONES.

5. The bones are formed of a species of cartilage, composed of gelatine, (the substance which constitutes strong glue) all the laminæ and all the fibres of which are incrusted with a strong matter composed of lime united to particular acids (phosphoric acid, &c.,) When bone is burned, the stony matter remains alone, and is reduced to powder by slight friction, and when bone is steeped in a particular liquid, which has the property of dissolving this stony matter, (hydrochloric acid) it is reduced to the state of a flexible cartilage.

6. In infancy bone is at first cartilagenous, and before ossification is complete, each one is formed of several distinct pieces which run together, as it were, at a later period.

7. The bones that constitute the skeleton are united one to the other by *articulations* or joints, which change their name according to their form.

8. If the articulation that unites two bones permits them to move, one on the other, it is called a *moveable* articulation.

9. If on the contrary the articulation is merely to secure the solidity and firmness of the bones, it is called *immoveable.*

10. The more moveable an articulation the less solid it is, and *vice versa;* the more solid, the less mobility it possesses.

11. The immoveable articulations take place through the medium of asperities which dove-tail together; this mode of union is called a *suture.*

12. The articular surface of the moveable bones (*plate* 6. *fig.* 4.) is covered with an elastic substance which is capable of bearing the strongest pressure, and which deadens the shocks they receive; this substance is called *cartilage.* The articulations are also supplied with a viscous fluid called *synovia*, designed

4. What is the skeleton? What are its uses?
5. Of what are the bones composed?
6. What is the condition of bone in infancy?
7. How are the bones joined together?
8. What is a moveable articulation?
9. What is meant by an immoveable articulation?
10. Which kind of articulation is most solid?
11. What is a suture?
12. How are the articulating surfaces of moveable bones protected from the effects of friction? What is the use of synovia?

to favor the sliding of the articular surfaces upon each other. The extremities of the bones that concur to form an articulation correspond by having their respective configurations reciprocal; they are, in general, one convex, the other concave.

13. The means of union between bones is by fibrous parts which bear the name of *ligaments.* These are very strong bands or species of cords which surround the articulation or joint, holding together the two bones by their extremities.

14. The articulations present a great variety in the motions of which they are susceptible.

15. The bones are also very different in their forms, and on account of this curcumstance they are divided into long, short and flat bones.

16. The long bones are generally cylindrical, of considerable size, and in the interior, hollowed into a canal filled, with a fatty matter called *marrow;* this form, without injuring their solidity, diminishes their weight. At their extremities these bones are enlarged to afford a broader surface for the articulation.

17. It is easy to perceive that, if the bones were in contact by small surfaces, their union would have been less solid, they would have afforded only an uncertain and insecure motion, and their derangement would have been as common as it is now rare.

18. About their middle, the long bones are formed almost entirely of very compact substance; but at their swollen extremities they are chiefly composed of a spongy substance, which is not so heavy. It is these bones that form the solid frame work of the limbs.

19. Neither the short nor the flat bones have any cavity in the interior.

20. The short bones are formed almost entirely of spongy substance, which lessens their weight without diminishing their volume. The chief use of the flat bones is to form the parietes of cavities which afford protection to internal organs: they are not however, insusceptible of motion; they furnish points of attachment to many muscles.

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13. What are ligaments?

14. Do the articulations permit of a variety of motions?

15. How are the bones divided?

16. What is the general character of the long bones? Where is the marrow found?

17. Why are the long bones enlarged at their extremities?

18. In what respect do the extremities and middle of the long bones differ in structure?

19. Have the short and the flat bones any internal cavities?

20. What is the character of the short bones?

21. We remark inequalities upon the surfaces of bones, which afford points of attachment for muscles; they often present for the same purpose, as well as for the ligaments of the joints, sallient prolongations which are named *apophyses* or *processes.*

OF THE SKELETON.

22. The skeleton is a species of frame formed by the union of the different bones of the body. A great many animals are without it, but it exists in the mammalia, birds, reptiles, and fish.

To study it we will select the skeleton of man (*plate* 6 *fig.* 1.)

23. The skeleton, like the body, is divided into head, trunk, and extremities.

24. The *head* is placed at the superior extremity of the body, and is divided into two parts, the cranium and face.

25. The *face* presents five great cavities destined to lodge the organs of sight, of smell, and of taste: these cavities are the two orbits (*for the eyes*) the two nasal fossæ and the mouth.

26. A great number of bones concur to form the face: the principal ones, are:

1st. The two *superior maxillary* bones, which constitute nearly the whole of the upper jaw, and rise at the sides of the nose to join the frontal bone.

2nd. The *malar* or cheek bones, which form the cheeks in part, and extend from the superior maxillary to the frontal bone so as to complete the orbit on the outside.

3rd. The *inferior maxillary* bone, which constitutes the lower jaw, presents nearly the form of a horse shoe.

There are also other bones in the face called *palate, nasal, unguiforme* or *lochrymal, spongy* bones, and *vomer.*

27. The *cranium* is a bony cavity of an oval form serving to contain the brain. It is formed by the union of several flat bones which are: in front, the *frontal,* upon the sides and above the *parietal,* behind the *occipital,* below, and on the sides the *temporal,* and in the middle the *sphenoid,* and inferiorly and in front the *ethmoid,* which also serves to complete the orbits and form the superior part of the nasal fossæ.

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21. For what purposes are those inequalities which are found on the surfaces of bones? What are proeessess?

22. What is the skeleton? Is every animal provided with a skeleton?

23. How is the skeleton divided?

24. What is the situation and division of the head?

25. What are the uses of the several eavities of the face?

26. What are the ehief bones of the face?

27. Describe the cranium?

28. On the sides of the cranium we remark an opening for the auditory canal, and on its inferior face or base we find many holes which serve to give passage to nerves and blood vessels. One of these holes, very much larger than the others, called the *occipital* hole—*foramen occipitale*—corresponds with the vertebral canal and gives passage to the spinal marrow. And on each side of this great hole we find an eminence called *condyle* which serves for the articulation of the head upon the vertebral column.

29. The *trunk* is composed of the *vertebral* column, the *ribs* and *sternum.*

30. The *vertebral column* or *spine* is a species of bony stalk or stem which occupies the middle line of the back, and extends from the head to the posterior extremity of the body; (*Plate* 6. *fig.* 2.) it is formed by the union of small, short bones called *vertebræ*, (*Plate* 6. *fig.* 3.) and presents throughout its whole length a canal formed by the union of the holes by which each vertebra is pierced; this canal serves to lodge the spinal marrow. Each of these bones presents in front of the hole, a species of thick, solid disc, called the body of the vertebra, which is very firmly united to the body of the vertebra next to it; behind, we remark prolongations called *transverse* and *spinous* processes which form what is commonly called the *spine.*

31. The vertebral column is divided into five regions, namely:

32. 1st. The *cervical* region which constitutes the frame of the and neck: in man almost all the other mammalia it is composed of seven vertebræ.

33. 2nd. The *dorsal* or *thoracic region*, which gives attachment to the ribs which form the *chest* or *thorax;* the vertebræ of this region in man, are twelve in number;

34. 3rd. The *lumbar* region, which terminates the back below, in man is composed of five vertebræ;

35. 4th. The *sacral* region which articulates with the bones of the hips, is composed, in man, of five vertebræ so run or fused together, as to form but a single bone called the *sacrum*;

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28. Of what use are the several holes at the base of the cranium? What passes through the occipital hole? What do we find on each side of the occipital hole?

29. What parts compose the trunk?

30. What is the vertebral column? What is found in the vertebral canal?

31. Into how many parts is the vertebral column divided?

32. How many vertebræ are found in the cervical region?

33. What is the number of dorsal vertebræ?

34. What is the number of lumbar vertebræ?

35. What is the sacrum?

36. 5th. The *caudal* or *coccygian* region, which in man is composed of four very small vertebræ, concealed beneath the skin, in many animals, is very long, constituting the tail.

37. The vertebral column seen in profile, presents four curves, which correspond to the neck, the back, the loins, and the *pelvis*, or basin, and which serve to augment its solidity. On its sides, we find, between all the vertebræ, a hole which gives passage to a nerve, coming from the spinal marrow.

38. The *ribs*, which are attached to the dorsal vertebræ, are long, flat bones, which enclose the thorax on each side: they are curved and bear considerable resemblance to a half hoop. In man there are twelve pairs. The seven first, called true ribs, articulate in front with the sternum, through the medium of a cartilage; the five last pairs, called false ribs, terminate anteriorly by a cartilage which joins that of the preceeding rib, or they are entirely without cartilage.

39. The *sternum* is a flat bone placed in front of the thorax; it articulates with the ribs and with the clavicles.

40. The *superior* or *anterior extremities* are composed of the shoulder, the arm, the fore-arm and the hand.

41. The *shoulder* is the basis of the whole limb attached to it. It consists of two bones; the *scapula* or shoulder blade, and the *clavicle*, or collar-bone.

42. The *scapula* is a large bone nearly triangular in shape, which is applied against the ribs at the superior and lateral part of the back. At its superior external angle, it presents an enlarged articular surface, slightly hollowed, which receives the bone of the arm and is called the *glenoid cavity of the scapula*. On the posterior face of this bone there is a projecting comb or ridge which extends over the articulation of the shoulder, and articulates with the clavicle. This prolongation is named the *acromion*.

43. The *clavicle* is a long thin bone situated at the base of the neck; it extends like a buttress between, the scapula and sternum;

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36. What are those vertebræ called which form the skeleton of the tail in animals?

37. For what use are the several holes found between the vertebræ on the sides of the spinal column?

38. What are the ribs? What number of ribs belong to man? How many are true and how many are false ribs?

39. What is the sternum?

40. How are the superior extremities divided?

41. What is the shoulder? What bones compose the shoulder?

42. Where is the scapula placed? What is the glenoid cavity? What is the acromion?

43. What is the use of the clavicle?

and serves to keep the first of these bones in its natural position, and to prevent the shoulder from falling too far forward.

44. The *arm* is formed of a single bone called the *humerus*. This bone is of a cylindrical form and has a swelling at its superior extremity called the head of the humerus which articulutes with the glenoid cavity of the scapula. Its inferior extremity is enlarged transversely and resembles a pully upon which moves the fore arm.

45. The *fore-arm* is formed by the union of two bones which are; on the inner side, the *cubitus* or *ulna*, and on the outside, (the side on which the thumb is placed) the *radius*. These bones are joined to the humerus by their superior extremities and to the hand by their inferior.

46. The hand in man is divided into three regions; the *carpus*, the *metacarpus* and fingers; the *carpus* or wrist, is composed of eight small bones, ranged in two rows and united to each other by fibrous threads which preserve their mutual relations and permit them to move a little upon each other, by aid of the smooth surfaces by which they are in contact.

47. The *metacarpus* is composed of five bones which may be regarded as the origin of the fingers. They are placed parallel, one along side of the other; their superior extremities articulate with the bones of the carpus and their inferior extremities with the fingers.

48. The *fingers* are composed of small bones articulated one at the extremity of the other, and called *phalanges*. Except the thumb which has but two, each finger has three of these bones.

49. The *inferior extremities* are formed nearly in the same manner as the superior; the hip represents the shoulder, the thigh the arm; the leg the fore-arm, and the foot the hand.

50. The *hip* or *haunch* serves to support the abdominal member or lower extremity, as the shoulder sustains the thoracic member. It is formed on each side by a very large, and very strong bone, the *ilium*. These bones are united together in front, and behind they articulate with the sacrum, so as to form in conjunction with it at the bottom of the belly, a sort of bony belt called the *pelvis* or *basin*. In infancy, we find that the *ilium* bone consists of three separate portions one of which resembles

44. What is the character of the bone of the arm?
45. How is the fore arm formed?
46. How is the hand divided?
47. What is the metacarpus?
48. How are the fingers composed?
49. How are the inferior extremities formed?
50. What forms the hip? What is the condition of the pelvis in infancy?

the scapula somewhat, and is called the *ilium ;* the second placed in front, called the *pubis*, may, perhaps compare with the clavicle, and the third, situated below and behind, has received the name of *ischium*, and which supports the whole weight of the body when seated; with age these three bones become solidified into one. At the point where they unite, we find a very deep, circular cavity called the *cotyloid* or more commonly the *acitabulum*, in which is articulated the thigh bone.

51. The pelvis serves not only to support the lower extremities, but also assists in sustaining the weight of the viscera contained in the abdomen, and in forming the parietes of this cavity.

52. The *thigh* is formed of a single bone called the *femur*. This bone is articulated by its superior extremity with the hip bone, and by its its inferior extremity with the leg.

53. The *leg* is formed of two bones very solidly united to each other. The bone placed internally, very much larger than the other and called *tibia* articulates with the femur by its superior extremity. The bone which is placed externally does not quite reach to the femur, and is only united to the tibia; it is named *fibula*. In front of the articulation of the leg with the thigh is placed a small bone named *rotula* or *patella*, which is designed to strengthen the knee joint.

54. The *foot* is divided into three regions; the *tarsus*, the *metatarsus* and *toes*. It differs from the hand chiefly in the shortness of the fingers, that is, toes, their limited mobility and by the disposition of the tarsus.

55. The *tarsus* is constituted of the union of seven bones, one of which alone, called the *astragalus*, articulates with the two bones of the leg; another one of these bones, called the *calcis*, forms a considerable projection behind which constitutes the heel.

56. The *metatarsus* is composed of five bones which are united to the tarsus and to the bones of the toes, and which are arranged like the bones of the metacarpus.

57. Like the fingers, the *toes* are composed of phalanges, called first, second, and third phalanges. The great toe has but two phalanges, each of the others has three. All these little

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51. What are the uses of the pelvis?

52. What number of bones is in the thigh?

53. How many bones constitute the leg? What are they called? What is the patella?

54. How does the foot differ from the hand?

55. What constitutes the tarsus?

56. Of what bones is the metatarsus composed?

57. Of what bones are the toes composed?

bones are joined to each other by articular surfaces, the contact and junction of which are secured by fibrous ligaments.

OF THE MUSCLES.

58. All the great motions of the body are caused by the displacement or movement of some of the bones which form the skeleton; but these bones cannot move of themselves, and only change their position through the action of other organs attached to them, and which by contracting draw them after them.

59. These motor organs are the *muscles.* They are very numerous and constitute nearly one half of the total mass of the body. They are a species of ribbon or fleshy cords composed of fasciculi or bundles of fibres united together, and which have the property of contraction and elongation. (*Plate* 6, *fig.* 5. *and* 10)

60. When a muscle contracts it swells; its fibres, which in a state of repose, were straight fold in zigzag, (*Plate* 6. *fig.* 6. *and* 7.) and their two extremities are brought near to each other drawing also with them the parts to which they are affixed.

61. The two extremities of muscles are solidly fixed to the bones and to the other parts which they are designed to set in motion, such as the skin, through the medium of white cords, called *tendons, (plate* 6. *fig.* 5) or membranes of the same nature, named *aponeuroses* or *fasciæ.* In contracting, they must necessarily draw toward each other the two bones to which the tendons or aponeuroses are attached. An example will enable us better to understand this mechanism.

If we suppose the muscle *m.* (*Plate* 6. *fig.* 8. *and* 9.) to be attached to the humerus and to the ulna or cubitus which articulates with the first, by moveable flesh, it is evident that when this muscle contracts, these bones will approach each other. This example will give an idea of all the motions of the skeleton.

62. The number of muscles of the human body is very considerable; they are reckoned at 470; in general they form about the skeleton two layers and are distinguished into superficial and deep seated.

63. The muscles which are designed to move any particular bone are almost always placed around that portion of the skele-

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58. How are the great motions of the body produced?

59. What are muscles?

60. What changes take place by the contraction of a muscle?

61. To what parts are the extremities of the muscles attached? What is the necessary consequence of the contraction of a muscle?

62. What is the disposition of the muscles? How are they distinguished?

63. How are the muscles situated in regard to the parts they are destined to move?

ton which is situated between the bone to be moved and the centre of the body; for example, the muscles which move the head are situated on the neck; those which move the arm are on the shoulder; those which flex and extend the fore-arm surround the humerus, and those which flex and extend the fingers are placed upon the fore-arm; the same is true of the muscles of the lower extremities.

64. The muscles are divided into *flexors*, *extensors*, *rotators*, *elevators*, &c. according to the uses which they subserve.

65. The contraction of the muscles is determined by the action of the nervous system, and each muscle receives a nerve which is ramified in its substance.

66. This contraction is sometimes effected through the influence of the Will and sometimes independently of it.

67. The muscles whose action is dependent upon the Will belong to the functions of relation, and those whose motions are involuntary (the heart for example) belong to the functions of vegetative life.

68. The strength or power of a muscle depends partly upon its volume, and partly on the manner of its attachment to the bone which it moves.

69. All things being in other respects equal, the strongest muscles are the largest, and from exercise both their volume and strength are at the same time increased.

70. In the bodies of animals, the muscles and the bones are generally placed unfavourably for the power of motion, but very favourably for rapidity, as may be easily demonstrated by the elementary principles of mechanism.

71. The muscles not only serve to enable us to execute different motions, but they are also equally necessary to maintain the moveable bones in the positions proper to them, and their action determines the attitudes.

For example, the head by its own weight has a tendency to fall forward, but the contraction of the muscles on the back of the neck keep it erect.

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64. How are the muscles divided?

65. What determines the contraction of the muscles?

66. Is muscular contraction always the result of the influence of the will?

67. To what principal functions do the muscles belong?

68. Upon what does the strength or power of a muscle depend?

69. What is the effect of exercise upon the muscles?

70. Whether are the muscles and bones arranged more with a view to power or rapidity?

71. Do the muscles serve any other purpose than to produce motion?

OF THE ATTITUDES.

72. The term *attitude* is applied to any position of the body that is permanent during any considerable time.

[In order to explain the mechanism of the attitudes it will be necessary to enter into some of the details which properly belong to the study of physics.

73. All bodies when left to themselves, tend towards each other, from the influence of a general force called *attraction*, and the force with which one body attracts another, is great in proportion as its mass is larger comparatively than that of the attracted body.

74. Now, the mass of the earth being incomparably larger than that of the animals, plants, stones, and all other objects spread upon its surface, attracts them unceasingly, and tends to cause them to fall towards the centre of the globe.

75. In order that a body shall rest in the position it occupies, it must be sustained by something capable of resisting this force of attraction, and which does not give way under its weight, such as the solid surface of the earth itself, or an inflexible body placed between it and this surface.

76. We name, *base of support*, the points occupied by the points by which an object supports itself upon a resistant body, or the space comprised between these points.

77. In order that a solid body shall rest motionless or immovable, upon its base of support and not fall, it is not necessary that all its parts should be thus sustained; it is enough to sustain it by a single point, provided this point be placed in such a manner that if a part of the mass fall towards the earth, another part opposite to it and of equal weight, be elevated as much; the weight of one part counterbalancing the other. *Centre of gravity* is the name given to the point about which all points of a body reciprocally balance each other, and if it be sustained, it is sufficient to maintain the entire mass in place.

78. It follows then that to prevent a body from falling, it is sufficient that its base be placed vertically beneath its centre of gravity.

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72. What is meant by attitude?
73. What is attraction?
74. Why do all bodies tend to fall towards the centre of the globe?
75. What condition is necessary that a body may preserve its position?
76. What is meant by base of support?
77. What is meant by centre of gravity?
78. What is necessary to prevent a body from falling?

79. It is also easy to understand that its equilibrium will be more stable in proportion to the extent of its base; for then its centre of gravity may be more displaced, without the vertical line which passes through the centre of gravity, being carried beyond the limits of this base of support.

The more the centre of gravity is elevated above the base of support, the less firm on the contrary will be the equilibrium, for a smaller displacement from this point will then suffice to carry the vertical line, that descends from it, beyond the base of support, which soon causes the body to fall.]

The term *attitude* is applied to any position of the body that is permanent during any considerable time.

80. The principal attitudes of man are: lying, sitting, and the erect position on his feet, or standing.

81. When a man is lying on his back or on his belly, all parts of the body rest upon the earth: he is not then required to contract any muscle to keep them in place, and his position unites in the highest degree the two conditions of equilibrium, to wit; the greatest possible extent of the *base of support* and the proximity of the *centre of gravity* to this base. Hence the attitude of repose is that from which it is most difficult to fall.

82. In the sitting position the body rests upon the tuberosities of the ischium or haunch bones; the base of support is considerable, since it is represented by the pelvis, the extent of which is increased by the soft parts which cover it; this position also, next to lying, offers the greatest solidity; but it cannot be preserved without muscular action. When the back is supported, the muscles of the neck alone contract to preserve the head erect; but if the back is not supported (as when seated on a stool or a bench for example) then the greater part of muscles on the back of the trunk contract to prevent it from falling forward, and fatigue will sooner or later result from this permanent action.

83. When man is erect, the lower extremities sustain the body and transmit to the earth the weight which they support. Consequently these limbs must not bend under the load, and must be kept straight by the contraction of their extensor muscles.

84. In this position the centre of gravity of the whole body lies in the cavity of the pelvis, and the base of support is circum-

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79. Why is a body firm in proportion to the extent of its base?
80. What are the principal attitudes of man?
81. What position or attitude is preserved without muscular exertion?
82. What muscles are exerted to preserve the sitting position?
83. What supports the body when man is erect?
84. Where is the centre of gravity in the erect position? Where is the base of support in the erect position?

scribed by the space comprised between the two feet. Here a slight force is sufficient to destroy the equilibrium, and it is only by enlarging the base of support in one direction more than in another that a fall can be prevented.

The movements by which we regain the perpendicular in the base of support are in a measure automatic. Thus, to resist a force tending to make us fall forward the foot is rapidly advanced: if the body leans to the left we suddenly extend the right arm to re-establish the equilibrium, if a force tends to throw us backward, we put a foot behind and throw the body in advance. The man who has a large belly and the man bearing a heavy load upon his shoulders are both obliged to assume attitudes that change the position of the centre of gravity. The first carries the body backwards in order that the vertical line passing through this point may also fall between the two feet, and for the same reason, the second bends the body forward. A woman who carries an infant upon her right arm inclines the body to the left side: thus, we are constantly resorting to mechanics, even without possessing the most elementary notions of the science, and the most certain causes of our preservation are found in the continual application of physical laws, of which our reason has not the knowledge.

When an animal rests upon its four members at the same time, his standing is more firm, more solid and less fatiguing: for the base of support is then very large. Then, without inconvenience the feet may be much smaller than in the bipeds and consequently lighter.

OF LOCOMOTION.

85. The objects of the motions which we perform is either to change the position of certain parts of the body, or to transport us from one place to another.

86. The faculty of changing place is called *locomotion.*

87. The movements of progression by the help of which man and animals change place, are produced by certain parts of the body which being flexed, rest upon a resisting object, and being again immediately extended, push forward the rest of the body.

88. In man the organs of locomotion are the abdominal members, or lower extremities; in quadrupeds the thoracic as well as the abdominal members; and in birds that fly, the wings.

89. In *walking*, the body of man is moved alternately by one

85. What is the object of the motions which we perform?
86. What is meant by locomotion?
87. How is progression effected?
88. What are the organs of locomotion?
89. How is walking distinguished from running and leaping?

of the feet and sustained by the other, without his ever ceasing completely to rest on the ground. This last circumstance distinguishes walking from leaping and running, movements in which the body quits the earth for a moment and launches into the air.

90. In walking, one of the feet is carried forward, while the other is extended on the leg, and as this last member is supported on the ground, its elongation displaces the pelvis and throws the whole body forward. When the foot which was advanced alights upon the ground, the pelvis turns on the femur of that side, and the leg which was at rest behind, is flexed and carried front of the other, touches the earth and in its turn serves to sustain the body, while the other limb by being extended gives a new impulse to the pelvis. By the aid of these alternate movements of flexion and extension each limb in turn bears the weight of the body, as it would do when standing on one foot, and at each step the centre of gravity of the whole mass of the body is pushed forward.

Security in walking is always in a direct ratio to the degree of separation of the feet, and in an inverse ratio to the mobility of the surface that supports us. It is only at the end of a certain time that sailors walk securely upon the deck. When they have once "got their sea legs" it is very easy to recognise them on shore from the habit which they have of considerably separating the feet in walking.

91. *Leaping* or jumping is a movement by which a man projects himself into the air and again falls to the ground as soon as the effect of the impulsion is lost.

92. The mechanism of the leap consists entirely in the previous flexion of the joints and their sudden extension. When a jumper wishes to spring, he shortens himself by folding himself up as it were upon himself; the leg is flexed forward on the foot, the thigh is also flexed back on the leg, and the trunk with the pelvis are flexed forward on the thigh; and, when one wishes to spring with all his strength, the trunk is flexed upon itself like a spring. In these preliminaries of the leap, the lower extremities and the body describe a series of zigzags. At the moment of the leap all the articulations are extended at the same instant and raise the body with such rapidity that it leaps into the air like an elastic rod that had been bent to the ground, and then suddenly abandoned to its elasticity or spring.

90. What is the mechanism of walking?
91. What is leaping?
92. What is the mechanism of a leap?

93. It is easy to perceive that the parts which act most in the leap are the legs: indeed, it is upon them that the weight to be raised is most considerable. The facility and rapidity of the leap are always in direct ratio to the energy of the muscles, which determine the extension of the legs. It is observed that the most vigorous dancers and even great walkers have the calf strongly developed: indeed this part is formed of the muscles which effect the extension of the leg upon the foot.

94. Running partakes both of walking and leaping. There is always a moment in running when the body is suspended in the air, a circumstance which distinguishes it from rapid walking in which the foot that rests behind does not leave the ground until the forward one again touches it.

95. Swimming and flying are movements analogous to those of leaping, but which take place in water or in the air, fluids whose resistance to a certain extent, takes the place of that of the ground in the act of leaping.

96. When an animal is destined to live in water and to swim, its members have a different form from that of those animals which are organized for walking only. The limbs are then short and constitute a species of paddles or oars called *fins*. When the animal is designed to elevate himself in the atmosphere, the thoracic members on the contrary are very much expanded and are so arranged on each side of the body as to form a kind of moveable sail or fan fit to strike the air with force.

In one of the following lessons, when we consider the mammalia and birds we shall recur to the study of these organs, and we shall see how the same members may constitute in different animals, the instruments of prehension, of walking, of natation, or of flight.

We here conclude what we proposed to say generally, on the manner in which the principal phenomena of animal life are performed, and on the organs which serve as instruments for the exercise of the faculties with which animals are endowed.

We shall next proceed to study each of these animals in particular, and see in what way they differ from each other.

END OF THE FIRST BOOK OF NATURAL HISTORY.

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93. What is remarkable in the legs of great dancers and walkers?
94. What is the mechanism of running?
95. What are swimming and flying?
96. What is the character of those animals which are destined to live in water? What is the character of the limbs of those animals destined to elevate themselves in the air?

GLOSSARY.

Acoustic—relating to sound.

Absorption—The function of absorbent vessels, by virtue of which they take up substances from without or within the body.

Adult—A person arrived at maturity—full grown.

Aliment—Any substance, which, if introduced into the system, is capable of nourishing it and repairing its losses.

Alveolus—*in the plural*, Alveoli—Sockets of the teeth.

Anatomy—The description of the structure of animals. The word Anatomy properly signifies *dissection;* but it has been appropriated to the study and knowledge of the number, shape, situation, structure, and connexion, in a word, of all the apparent properties of organized matter, whether animal or vegetable: hence, vegetable anatomy and anatomy of animals.

Analogous—Resembling—Similar.

Analysis—The separation of the component parts of bodies.

Anfractuosity—A groove or furrow—used in anatomy to signify sinuous depressions, of greater or less depth, like those which separate the convolutions of the brain from each other.

Animal—A name given to every animated being provided with digestive organs.

Animalcule, Animalculum, Animalcula, } A diminutive animal—an animal only perceptible by means of the microscope.

Annelides—A class of animals without vertebræ—having no back-bone or spine.

Apparatus—A collection of instruments or organs for any operation whatever—An assemblage of organs.

Appendix—Any part that adheres to an organ, or is continuous with it—seeming as if added to it. *An appendage.*

Arachnides—Insects belonging to the genus of spiders.

Articulation—A joint—the union of bones with each other.

Asphyxia—Suspended Animation.

Atmosphere—The air which surrounds the globe.

Automatic—Spontaneous—That which acts of itself.

Azote—A gas which is unfit for respiration—It is one of the component parts of the atmosphere—It is also called nitrogen.

Botany—The natural history of plants.

Bile—A yellow, greenish, viscid, bitter, nauseous fluid: secreted by the liver. The gall.

Capsules—(dental) Membraneous pouches in which the teeth are formed.

Carbonic—Relating to carbon, a simple or uncompounded substance—The diamond is pure carbon.

Cartilage—Gristle—A solid part of the animal body of medium consistence between bone and ligament.

Chaos—Confusion.

Circulation—The act of moving in a circle.

Crustacea—A class of animals whose bodies are inclosed in a covering like the crab.

DERMA—The true skin.

DECIDUOUS—That which falls off—not permanent.

DEGLUTITION—The act of swallowing—The act by which substances are passed from the mouth into the stomach through the pharynx and œsophagus.

DIAPHANOUS—Permitting the passage of light in a partial degree, as oiled paper, or horn, or muslin. Translucent.

DIAPHRAGM—The fleshy or muscular partition, between the cavity of the chest and cavity of the abdomen or belly.

DIASTOLE—The dilatation of the heart when the blood enters its cavities.

ENCEPHALON—The brain and spinal marrow.

EPIDERMIS—The external covering of the Derma. It is commonly called the cuticle or scarf skin.

EPHEMERAL—Fleeting—transient—lasting but a day—Momentary.

EXCRETION—The separation, or throwing off of those matters from the body of an animal which are supposed to be useless, as perspiration, &c. The matters thrown off from the body as useless are termed excretions.

EXCRETORY—An *excretory vessel* or *duct*, is one which transmits the fluid secreted by a gland either externally or into the reservoirs in which it has to be deposited. *Excretory organ*, means any organ charged with the office of excreting: thus, the skin is said to be an excretory organ, because through it the perspiration or sweat takes place.

EXHALATION—That which exhales from any body. A function, by the virtue of which certain fluids, obtained from the blood are spread, in the form of dew on the surface of membranes, either for the sake of being thrown out of the body, or to serve for certain purposes—The sweat is an example of an exhalation, as well as of an excretion.

EXTEND—To straighten—to stretch out—when a limb is straightened it is said to be extended.

EXTERNAL—Outside—It is used in relation to the middle line of the body; for example, the little toe is external, and the big toe internal; the corner of the eye next to the nose, is the *internal* corner, and the other the *external* corner of the eye.

EXTREMITIES—The limbs; the legs and arms.

FIBROUS—Composed of fibres.

FILAMENT—A small thread.

FISSURE—A long narrow cleft.

FLEX—To bend.

FLEXION—The state of being bent.

FOLLICLE—A diminutive glandular sac or bag.

FORAMEN—In the plural FORAMINA—A hole.

FRUGIVOROUS—Fruit-eating—Those animals which live exclusively on fruits are called frugivorous.

FUNCTION—The action of an organ, or set of organs. We see by the actions or *functions* of the eye, and the functions of the ear enable us to hear.

GANGLION—A knot—nervous ganglions are enlargements or knots in the course of a nerve. They generally belong to the great sympathetic nerve.

GAS—Any substance or fluid which is permanently aëriform under the ordinary conditions of the atmosphere.

GASTRIC—Relating to the stomach.

GEOLOGY—The description of the structure of the earth.

HEMISPHERE—One half of a sphere or globe, or globular body; the brain is divided into two hemispheres.

Incisor, } Incisive, } Cutting—applied to certain teeth.

Insects—Animals without vertebræ, but which have jointed extremities, lungs or tracheæ for breathing, and the head distinct from the thorax; they are without a circulating apparatus, and generally have wings.

Internal—See, External.

Lamina—A plate—A thin piece.

Lobe—A round, projecting part of an organ.

Lymphatic—Relating to lymph.

Lymph—A name given to the fluid contained in the lymphatic vessels, and thoracic duct of animals.

Mammalia, } Mammiferæ, } Animals that suckle their young belong to the class of mammalia: having teats.

Mammiferous—Relating to the mammiferæ or mammalia: having teats.

Mastication—The act of chewing.

Material—Not spiritual—relating to matter.

Membrane—A name given to different thin organs, representing species of supple, more or less elastic, webs; varying in their structure and vital properties, and intended in general to exhale, absorb or secrete certain fluids, and to separate, envelope, and form other organs.

Membraneous, or Membranous—Relating to membrane.

Mineral—Any natural inorganic substance found in the earth or upon its surface; as for example, stones, clay, earth, metals, and metallic ores, &c.

Mineralogy—That department of Natural History which teaches us to describe, recognize, and classify the different genera and species of the objects of inorganic nature. As the greater part of these are solids, extracted from the earth by mining, they are called Minerals. The term fossil is now commonly restricted to such forms of organic bodies as have been penetrated with earthy or metallic matters.

Mollusca—A class of marine animals without vertebræ, having vessels, a nervous system but without articulated or jointed extremities.

Motor, } Motive, } That which moves, or gives the power to move.

Nasal—Relating to the nose.

Nitrogen—A gas—See azote.

Nutrition—The function by which the various organs receive the nutritive substances, necessary to repair their losses and maintain their strength.

Œsophagus—The gullet—A tube leading from the mouth to the stomach for the transmission of food.

Odoriferous—Bearing odors.

Organ—Part of an organized being, destined to exercise some particular function; for example, the ears are the organs of hearing, the muscles are the organs of motion, &c.

Organic—Relating to an organ.

Organized—Composed of organs; having a mode of structure.

Orbit—The bony cavities in which are lodged the eye-balls, with their muscles, nerves, lachrymal glands, &c., are called the orbits.

Oscillatory—Moving backward and forward like a pendulum.

Ossification—The formation of bones.

Oxygen—A gas which constitutes about one fifth of our atmosphere; which is necessary to the respiration of animals, and consequently indis-

pensable to animal life. But it cannot be breathed alone for any considerable time with impunity, requiring to be mixed with about four parts of nitrogen or azote, as is the case in our atmosphere, to render it suitable for respiration.

Parietes—The sides or walls of any hollow viscus, as the stomach, are termed its parietes.

Perspicuity—Clearness.

Petrous—Rocky—A portion of the temporal bone is so called on account of its *rocky* hardness.

Pharynx—The swallow.

Philosophy—Knowledge—The pursuit of truth.

Physiology—The science which treats of the functions of animals or vegetables—It is divided into animal physiology and vegetable physiology.

Politics—The science of government; the art or practice of administering public affairs.

Prelude—An introduction—something that indicates what is to follow.

Prehension—The act of taking hold of.

Primer—An elementary book—A first-book.

Pulmonary—Relating to the lungs.

Quadruped—Four-footed—Animals that have four feet are called quadrupeds.

Quadrumana—Four-handed—Animals having four hands, as monkeys, belong to the class of quadrumana.

Ramuscle.—A diminutive branch.

Sap—The nutritious liquid, or blood of plants.

Saliva—Spittle.

Salivary—Relating to saliva.

Sapid—Having a taste.

Science—Knowledge—Any art or species of knowledge.

Sensibility—The power or faculty of receiving impressions from surrounding objects, and being conscious of them.

Sense—The faculty of receiving impressions from external objects.

Secretion—The organic function of the several glands by which they separate from the blood the materials which they respectively demand for their several purposes: each organ according to its peculiar structure, differs from the rest, and hence we have the formation of the different fluids, as bile, saliva, milk, &c. The fluids thus elaborated or separated from the blood are also termed secretions.

Sinus—Any cavity, the interior of which is more expanded than the entrance.

Sinuous—Relating to sinus.

Skin—The dense, elastic membrane which envelopes the body. It consists of three layers or laminæ; the *derma*, *epidermis* and *rete mucosum*, the last being placed between the other two. The color of the different races of men depends upon the color of this *rete mucosum;* the other two layers being alike, or nearly so, in the whole human family.

Sonorous—Yielding sounds.

Sternum—The breast bone.

Suture—An immoveable joint.

Symmetrical—A term applied to those parts of the body, which if seated on the median line, may be divided into two equal, and perfectly like halves:

or which, if situate—the one to the right and the other to the left of this line—have a similar conformation, and a perfectly analagous arrangement.

Syncope—Fainting—Complete loss of sensation and motion, with considerable diminution or *entire* suspension, of the pulsations of the heart and the movements of respiration. Hence, syncope resembles death.

Synovia—The lubricating fluid of the joints, which enables the surfaces of bones and tendons to glide smoothly over each other.

Systole—The contraction of the heart, by which it gives impulse to the blood or causes its progression in the blood vessels.

System—An arrangement according to some plan or method.

Tears—The fluid secreted by the lachrymal gland, and poured between the globe of the eye and the eye-lids, to facilitate the motions of those parts.

Thoracic—Relating to the thorax or chest.

Tissue—Texture—The various parts, which, by their union form the organs. The term is applied to the different kinds of organization or structure of the body, as for example, the *muscular* tissue, *osseous* tissue, meaning the structure of which the muscles, and bones are composed.

Trachea—The wind-pipe.

Transfusion—The act of injecting blood freshly drawn from one animal into the veins of another. It has been successfully resorted to in cases of disease.

Translucent—Permitting the passage of light—Diaphanous.

Transparent—That which may be seen through, as glass, &c. Objects cannot be clearly discerned through bodies that are merely *diaphanous*, or even *translucent*, while they may be, through bodies that are *transparent*.

Valve—A small door. Any membrane or doubling of membrane which prevents fluids from flowing back in the vessels and canals of the animal body.

Vesicle—A diminutive bladder or sac.

Vibration—The act of moving in quick returns; quivering.

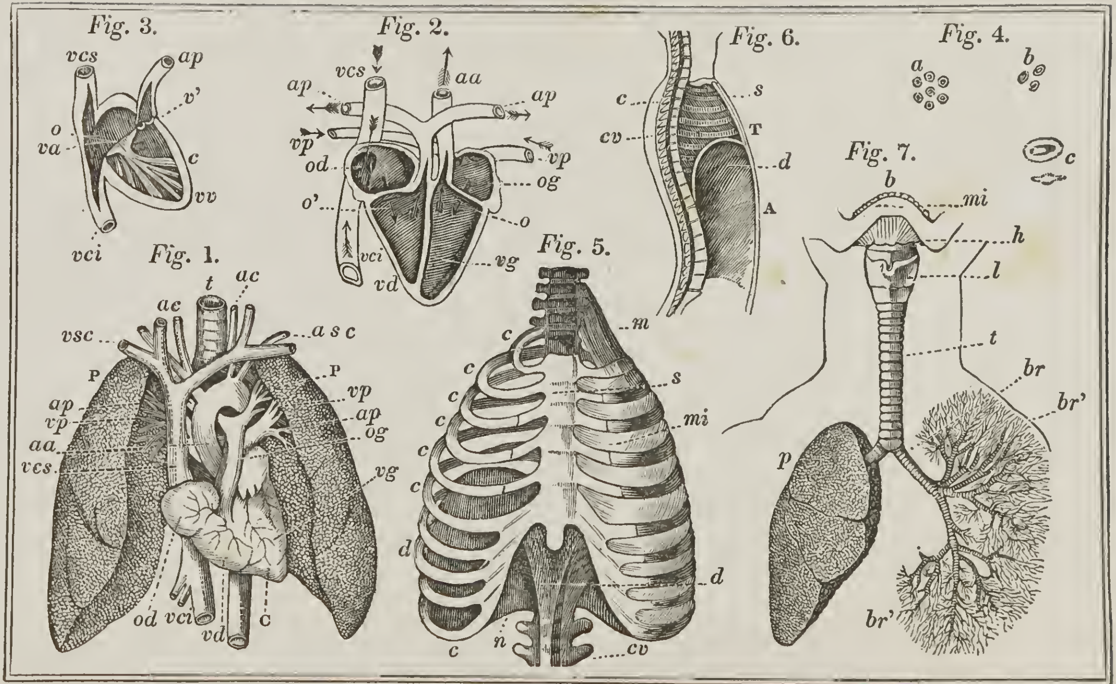
Viscid, Viscous, } Glutinous; sticky; tenacious.

Viscus—Any bowel or entrail, or internal part, as the heart, liver, lungs, pancreas, &c.

Vitreous—Resembling glass—glassy.

Vomer—The bone which forms the solid part of the partition between the two nostrils, is called vomer, from its fancied resemblance to a plough-share.

FINIS.



Organs of the Circulation and of Respiration.

EXPLANATION OF PLATE 1.

Fig. 1. The lungs of man with the heart and great vessels which arise from it—PP. the lungs,—*t*. the trachea which conveys air to the lungs,—c. the heart,—*o. d.* the right auricle of the heart.—*v. d.* right ventricle of the heart,—*o. g.* left auricle of the heart.—*v. g.* left ventricle of the heart.—*v. c. s.* and *v. c. i.* superior and inferior venæ cavæ, emptying into the right auricle of the heart,—*a. p.* pulmonary artery going from the right ventricle to the lungs,—*v. p.* pulmonary veins, passing from the lungs to the left auricle of the heart—*a. a.* the aorta,—*a. c.* carotid arteries arising from the aorta and conveying blood to the head,—*a. s. c.* subclavian veins coming from the arms and emptying into the superior vena cava.

Fig. 2. The heart, opened to show the cavities in the interior of this organ. The different parts are indicated by the same letters as in the preceding figure; the arrows point out the direction of the flow of blood in the different vessels.—*o*, left auriculo-ventricular opening.—*o*'. right auriculo-ventricular opening.

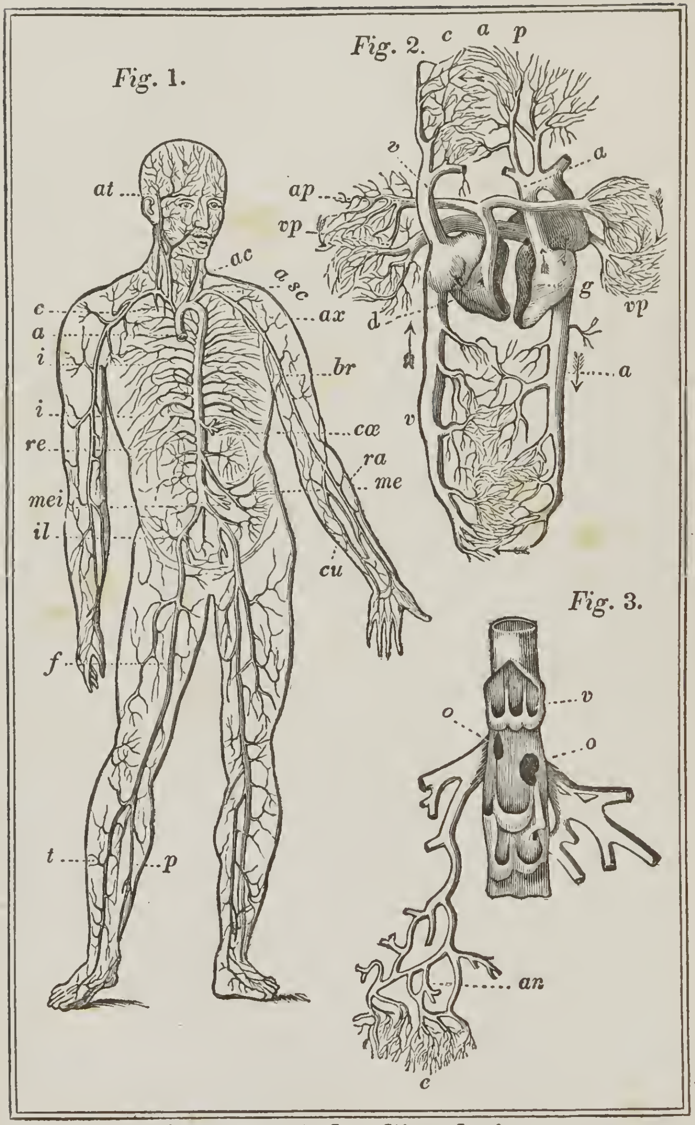
Fig. 3. The right side of the heart, opened to show the position of the valve, *va*, in the auriculo-ventricular opening, which, during the contraction of the ventricle (*vv*,) prevents the blood from entering the auricle (*o*.;) we observe small cords passing from the edge of this valve and attaching themselves by their inferior extremities to the parietes of the ventricle (c.) Like the rest of the heart, they are fleshy and prevent the valve from turning entirely over into the auricle, when the blood, pressed by the ventricle, elevates it. The aorta is also open to show the valves (*v*') which surround its entrance and which are differently arranged from those of the ventricle.

Fig. 4. Some globules of blood as seen in a microscope.—*a*. circular globules of the blood of a mammiferous animal—*b*. globules of the blood of a bird,—*c*. globules of the blood of a frog; one of these globules is seen in front, the other in profile.

Fig. 5. The thorax. On one side are left the muscles which fill the spaces between the ribs; on the opposite, they have been removed.—*c. v.* the vertebral column, the greater part of which is concealed by the sternum—*c, c, c,* ribs—*m, i.* intercostal muscles—*s*, the sternum—*d*, the diaphragm; a part of which is seen below the thorax, and between the ribs on the right side, but it is concealed on the left by the ribs and intercostal muscles.

Fig. 6. A vertical section of the trunk to show the position of the diaphragm (*d*.) which separates the abdomen (A.) from the thorax (T,) into which it rises up like an arch,—*c. v.* vertebral column—*c*. ribs—*s*. sternum.

Fig. 7. The lungs and trachea; on one side the lung is represented entire, and on the other, the canals which convey the air into the interior of all the cells of this organ—*b*, the mouth—*m. i.* the lower jaw—*h*, the hyoid bone—*l*. the larynx—*t*. the trachea—*br*. the bronchiæ—*br*'. ramuscules, or small branches of the bronchiæ—*p*. the lungs.



Organs of the Circulation.

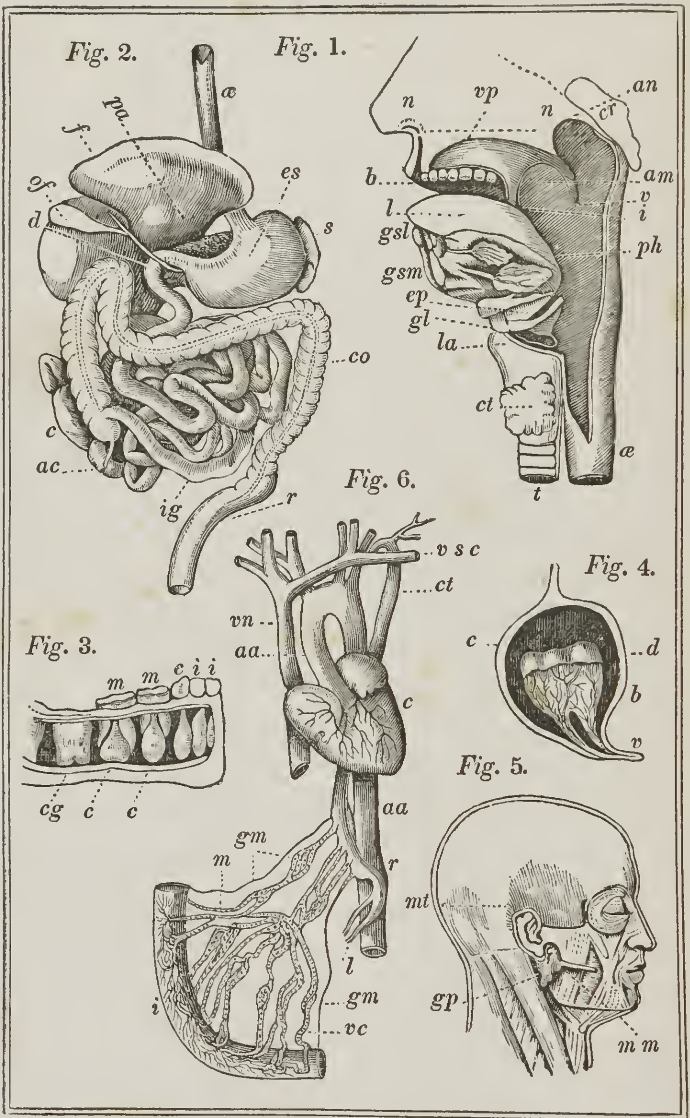
EXPLANATION OF PLATE 2.

Fig. 1. The aorta and the branches which arise from it to convey the blood to all parts of the body—*a.* the aorta—*c.* arch of the aorta—*a. c.* carotid arteries—*a. t.* temporal arteries—*a. sc.* subclavian arteries—*ax.* axillary artery—*br.* brachial artery—*r. a.* radial artery—*c. u.* cubital or ulnar artery—*i*, *i*, intercostal arteries—*cœ.* cœliac artery —*r. e.* renal arteries—*me.* and *mei.* superior and inferior mesenteric arteries—*il.* iliac arteries—*f.* femoral arteries—*t.* tibial artery—*p.* the peroneal artery.

Fig. 2. This figure does not represent the natural arrangement of the heart and blood vessels; it is an ideal diagram designed to convey some notion of the way in which the blood, in completing the entire route of the circulation, passes twice through the heart, and also passes through the two systems of capillary vessels, namely, those of the lungs in getting from the pulmonary artery into the pulmonary veins, and those of all the organs, in passing from the minute terminating branches of the aorta into the radicals of the veins which end in the venæ cavæ. The two halves of the heart, which in reality are only separated by a partition, are here completely isolated.—*g.* left side of the heart—*a.* the aorta—*c. a. p.* capillary vessels which terminate the arteries, all of which spring from the aorta—*v.* general venous system—*d.* right side of the heart—*a. p.* pulmonary artery—*v. p.* pulmonary vein.—The arrows point in the direction of the current.

Fig. 3. A large vein opened to show the valves (*v.*) which are found in these vessels—*o.* opening of one of the branches—*an.* anastomosis of two veins,—*c.* capillary roots of the vein.

Plate 3.



Organs of Digestion.

EXPLANATION OF PLATE 3.

Fig. 1. A vertical section of the head and neck, to show how the wind-pipe or trachea opens into the swallow or pharynx, and how this last cavity communicates with the mouth and nasal fossæ or nostrils.—*b*. the mouth,—*l*. the tongue.—*vp*. arch of the palate which separates the mouth from the nasal fossæ.—*n*. nasal fossæ opening externally by the nostrils and communicating with the swallow by the posterior nares or hind nostrils (*an.*)—*i*. isthmus of the fauces—*am*. tonsils. —*v*. vail of the palate.—*ph*. the swallow or pharynx cleft or divided like the mouth and nasal fossæ.—*œ*. æsophagus, a tube which descends from the swallow to the stomach.—*la*. larynx, the superior opening of which called the glottis, *gl*. is placed at the anterior and inferior part of the swallow: we see upon this organ a species of little tongue or valve, called epiglottis, (*ep.*)—*t*. trachea or wind-pipe which descends from the larynx into the lungs.—*cr*. base of the skull.—*gsm*. sub-maxillary gland.—*gsl*. sublingnal gland.—*ct*. thyroid gland.

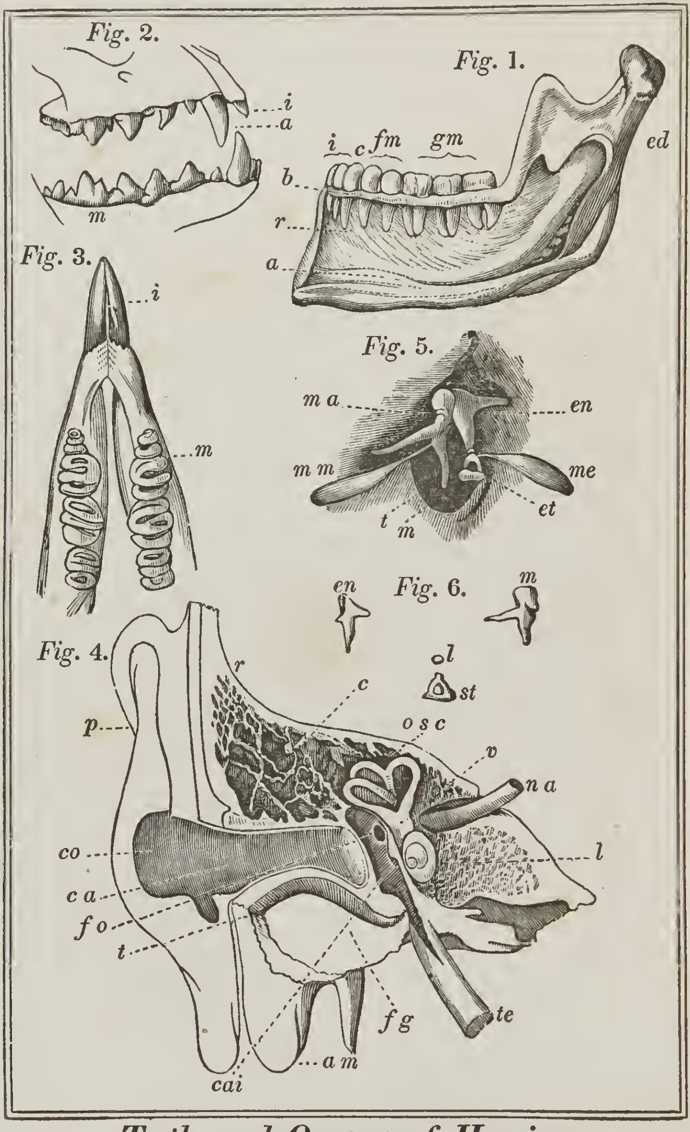
Fig. 2. Principal organs of digestion—*œ*. œsophagus or gullet.—*es*. stomach.—*d*. the duodenum, the first part of the small intestines.—*ig*. the small intestines.—*c*. the cæcum.—*ac*. the coecal appendix or appendix vermiformis.—*co*. colon.—*r*. rectum.—*f*. the liver—*of*, the gall bladder.—*pa*. the pancreas.—*s*. spleen.

Fig. 3. The lower jaw of a very young infant, opened to show the capsules of the teeth. The milk teeth are here developed and there are five on each side: namely, two incisors (*i.*) one canine (*c.*) and two molars (*m.*); we see below them the capsules of the incisor, canine and false molar teeth of second dentition, (*c*) and further back the capsules of the great molars (*cg*)

Fig. 4. One of the dental capsules opened to show the fleshy tubercle or granule which is in it.—*b*. the tubercle upon which the tooth in a manner moulds itself.—*v*. blood vessels and nerves which enter into this little secreting organ.—*d*. part of a tooth which has just begun to form.—*c*. capsule.

Fig. 5. The head seen in profile to show the parotid gland (*g. p.*) and the chief levator or elevating muscles of the lower jaw, namely, the temporal (*m. t.*) and maseter muscles. (*m. m.*)

Fig. 6. Represents a portion of the small intestine (*i*) upon which we see the chyliferous vessels, the thoracic duct and the course followed by the chyle to reach the veins.—*m*. part of the peritoneum which serves to hold the intestines in their place, and which is called mesentery.—*vc*. chyliferous vessels.—*gm*. mesenteric glands.—*r*. reservoir of Pecquet or receptacle of chyle, which is a slight dilatation of the thoracic duct, soon after its commencement.—*l*. lymphatic vessels coming from all parts of the body to the receptacle of the chyle.—*c. t*. thoracic duct which ascends along side the aorta, (*a. a.*) passes behind the heart (*c.*) and empties into the left sub-clavian vein. (*v. s. c.*) *v. n*. vena cava, descending to the right auricle.



Teeth, and Organs of Hearing.

EXPLANATION OF PLATE 4.

Fig. 1. Lower jaw of a man opened to show the manner in which the roots of the teeth (*r.*) penetrate its substance (*a.*)—*b.* the superior edge left entire—*i.* incisor teeth.—*c.* canine teeth.—*fm.* false molar teeth.—*gm.* great molar teeth.—*ed.* condyle of the jaw which enters into its articulation with the cranium.

Fig. 2. Teeth of an animal of the order carnaria.—*i.* incisors.—*a.* canine.—*m.* molar teeth.

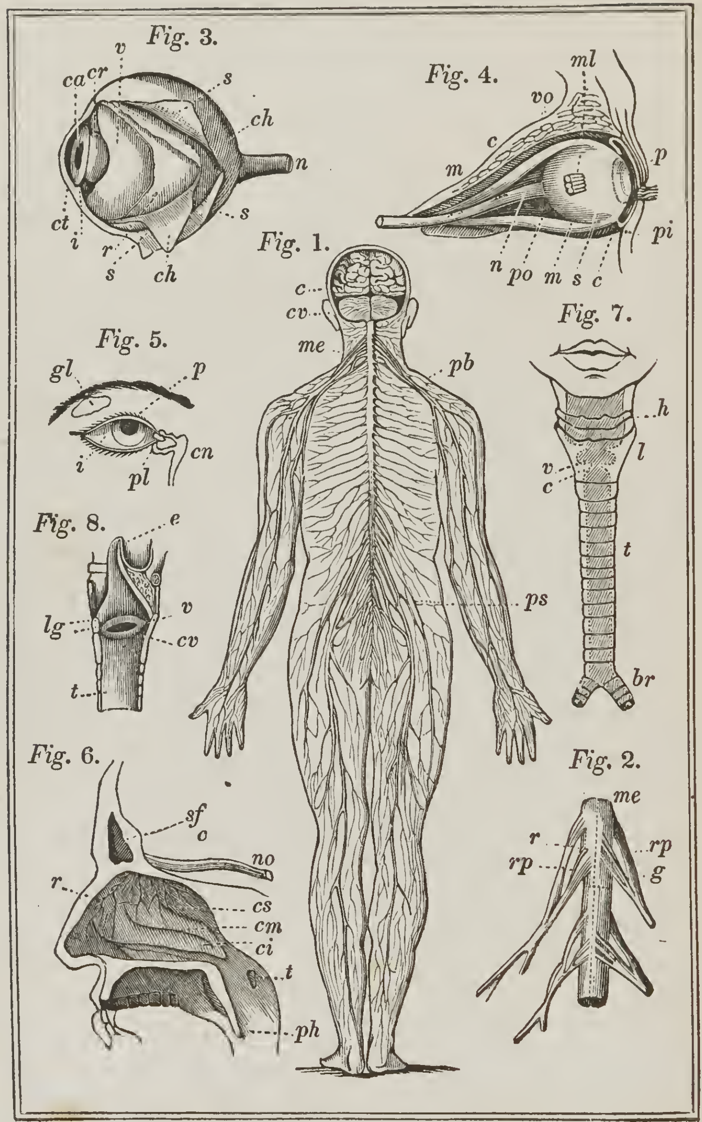
Fig. 3. Teeth of an animal of the order rodentia.—*i.* incisor teeth.—*m.* molar teeth.

Fig. 4. A vertical section of the organ of hearing.—*p.* pavilion of the ear.—*co.* concha.—*c. a.* auditory canal.—*t.* tympanum behind which is seen the cavity of the tympanum (*cai.*)—*t. e.* the Eustachian tube.—*f. o.* foramen ovale.—*v.* the vestibule,—*l* the cochlea.—*o. s. c.* the semicircular canals—these canals and the cochlea constitute the labyrinth or internal ear.—*n. a.* the auditory or acaustic nerve.—*r.* the petrous bone, that is a part of the temporal bone which derives its name from a Greek word signifying, rocky, which has been applied to it from its very remarkable hardness.—*c*, cells in the temporal bone.—*f. g.* glenoid cavity for the articulation of the lower jaw.—*a. m.* mastoid apophysis or mastoid process of the temporal bone.

Fig. 5. The tympanum with the bones of the ear.—*t.* the tympanum.—*m. a* the maleus or hammer.—*m.* the handle of the maleus which rests upon the tympanum.—*m. m.* muscle of the maleus.—*en.* the incus or anvil.—*et.* the stapes or stirrup.—*me.* muscle of the stapes.

Fig. 6. Bones of the ear separated.—*m.* the maleus.—*en.* the incus.—*l.* the os lenticulare or lenticular bone, or orbicular bone.—*st.* the stapes.

Plate 5.



Nervous System—Organs of Sense.

EXPLANATION OF PLATE 5.

Fig. 1. The nervous system.—*c.* the cerebrum.—*cv.* the cerebellum.—*m. e.* the spinal marrow from which arises a great many nerves which ramify over all parts of the body.—*pb.* the brachial plexus or reunion or assemblage of the different nerves which are distributed to the arms.—*p. s.* the sciatic plexus or of assemblage of nerves which form the great sciatic nerve which descends to the lower extremities.

Fig. 2. A portion of the spinal marrow to show the manner in which the nerves arise by two sets or bundles of roots.—*r.* anterior roots serving for motion.—*r. p.* posterior roots serving for sensibility.—*g.* ganglionic swelling of a posterior root.

Fig. 3. An open eye.—*s.* the sclerotica, one part of which is turned back —*ch.* the choroid.—*r.* the retina.—*c. t.* the transparent cornea.—*c. a.* the anterior chamber.—*i.* the iris, the centre of which is pierced by the pupil.—*cr.* the chrystaline lens.—*v.* the vitreous humor.—*n.* the optic nerve.

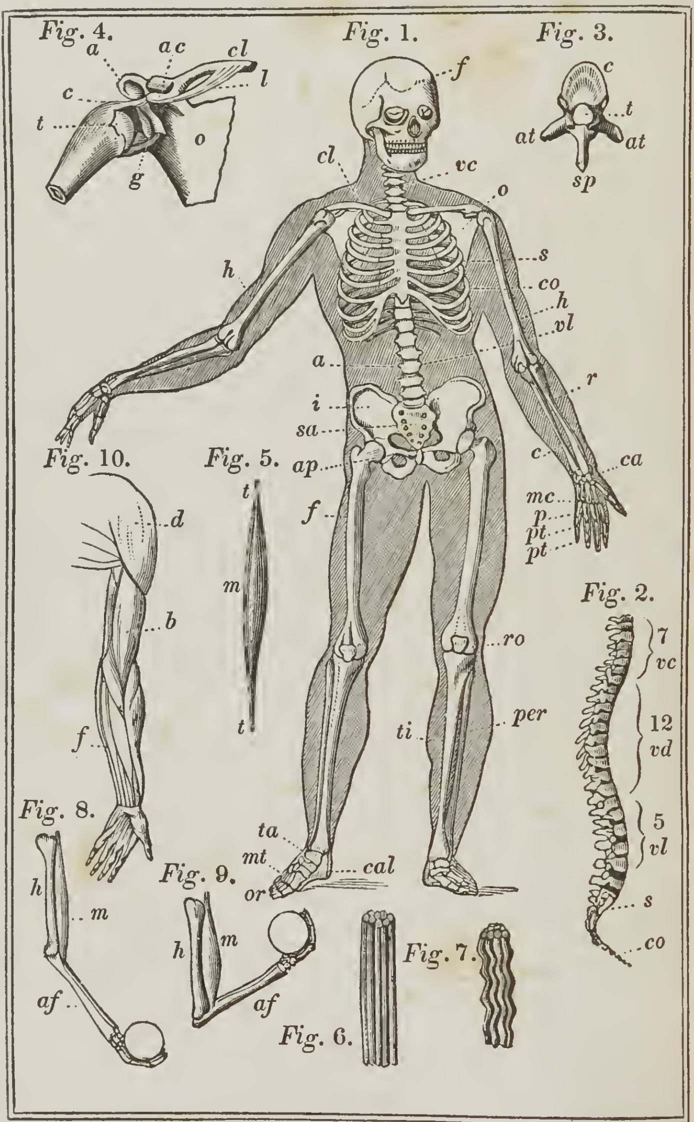
Fig. 4. The orbit open to show the position of the eye in this cavity and the muscles which move it.—*c.* the cranium.—*v. o.* the orbitary arch.—*po.* the floor of the orbit.—*p.* and *pi.* the upper and lower eye-lids.—*s.* the globe of the eye.—*c.* the conjunctiva.—*n.* the optic nerve.—*m. m.* two muscles of the eye.—*m. l.* a third muscle cut so as to afford a view of the optic nerve.

Fig. 5. The eye seen in front.—*p.* the pupil, and *i.* the iris seen through the transparent cornea.—*g. l.* the lachrymal gland.—*p. l.* the lachrymal points or puncta lachrymalia.—*c. n.* the nasal canal.

Fig. 6. The nasal fossæ open and seen from the inside.—*c.* the cranium *s. f.* the frontal sinuses, cavities hollowed out in the substance of the frontal bone, and in communication with the nasal fossæ.—*n. o.* the olfactory nerve *r.* its branches ramifying on the pituitary or schneiderian membrane.—*cs, cm, ci.* superior, middle and inferior turbinated bones; these are projecting plates of bone which serve to increase the extent of the surface of the organ of smell—*ph.* the swallow or pharynx—*t.* the opening of the Eustachian tube.

Fig. 7. The larynx seen in front. The internal line indicates the shape of the internal surface of this organ.—*h.* the hyoid bone.—*l.* the larynx. —*t.* the trachea.—*br.* the bronchiæ.—*c. v.* vocal cords.

Fig. 8. The larynx open, seen from one side.—*e.* the epiglottis.—*v.* one of the ventricles of the larynx.—*lg.* the superior ligament of the larynx.—*c. v.* one of the vocal cords.—*t.* the trachea.



Organs of Motion.

EXPLANATION OF PLATE 6.

Fig. 1. Skeleton of man; the external line indicates the shape of the body—*f.* the frontal bone—*v. c.* the cervical vertebræ—*s.* the sternum or breast bone—*co.* the ribs—*v. l.* the lumbar vertebræ—*a.* the abdomen—*sa.* the sacrum—*cl.* the clavicle—*o.* the scapula or shoulder blade—*h.* the humerus—*r.* the radius—*c.* the cubitus or ulna—*ca.* the carpus—*mc.* the metacarpus—*p.* and *pt.* the phalanges or bones of the fingers—*i.* the ilium—*f.* the femur—*ro.* the rotula, patella or knee-pan—*ti.* the tibia—*per.* the fibula—*ta.* the tarsus—*mt.* the metatarsus—*or.* the toes—*cal.* the calcis or heel.

Fig. 2. The vertebral column seen in profile—*vc.* the cervical region composed of seven vertebræ—*v. d.* the dorsal region—*vl.* the lumbar region—*s.* the sacrum—*co.* coxyx.

Fig. 3. A vertebra seen from above—*c.* body of the vertebra—*t.* a hole for the passage of the spinal marrow—*a. t.* transverse processes—*s. p.* spinous process directed backwards.

Fig. 4. The articulation (joint) of the shoulder, showing how the moveable bones are attached to each other—*o.* the scapula—*t.* the head of the humerus—*c.* the capsule of the articulation opened—*g.* glenoid cavity of the scapula—*a.* the acromion process of the scapula, articulating (jointing) with the clavicle (*c. l.*)—*a. c.* coracoid process of the scapula—*l.* ligament extending from this process to the clavicle.

Fig. 5. A muscle (*m.*) with the tendons (*t. t.*) by which it is attached to the bones.

Fig. 6. A fragment of muscle, showing the muscular fasciculi (bundles of muscular fibres) straight, and at rest.

Fig. 7. The same in a state of contraction.

Fig. 8. Bone of the arm (*h.*) and the fore-arm (*af.*) with one of the flexor muscles of the fore-arm (*m.*) in a state of rest.

Fig. 9. The same at the moment of contraction.

Fig. 10. The muscles of the superior extremity—*d.* the deltoid muscle, which extends from the shoulder to the arm, and by contracting, elevates the latter—*b.* the biceps muscle which bends the arm—*f.* one of the flexor muscles of the fingers.